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GENERAL SCIENCE QUARTERLY

... CONTENTS ...

A Study of Achievement and Subject Matter in General Science. *August Dvorak* . . . 367

Science Meeting Tomorrow's Needs. *B. Clifford Hendricks* 397

A Lesson in Osmosis. *John V. Jewett* . . . 400

The Scientific Method and Health. *Paul I. Pierson* 402

The Value of Astronomy in a General Science Course. *H. A. Richardson* 407

Teaching Science vs. Teaching Facts. *Lowell C. Frost* 412

More Science in Elementary Schools Urged. *R. G. Jones* 418

Way Clocks Keep Time. *O. E. Underhill* . . 420

Motion Pictures 426

The New Books 429

Science Articles in Current Periodicals . . . 436

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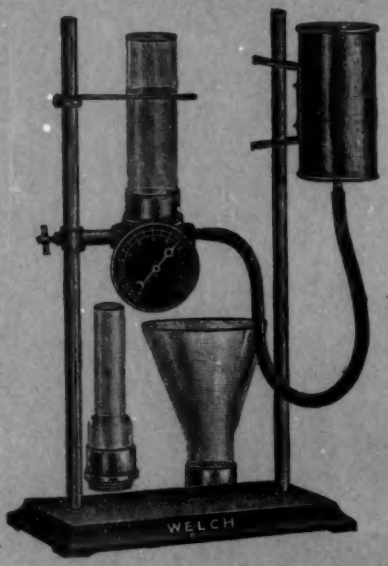

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A Study of Achievement and Subject Matter in General Science

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CHAPTER V.

RELIABILITY OF THE GENERAL SCIENCE TEST.

It is needless to say that if the General Science test were unreliable, any comparisons or developments of that test would carry with them the same unreliability. Therefore, before proceeding further with the exposition of this study, statement will be made concerning the reliability of the original 300 item General Science test given to approximately 11,000 pupils.

Study of results has shown that the original test, with its inherent faults of extreme length and of a few valueless items, was highly reliable. Evidence of this reliability of the test is presented in terms of the following criteria: (1) Retesting; (2) Permanency or stability of the pupils' correct and incorrect responses; (3) High positive correlation with other criteria of known value; (4) Correlation between a part and the whole of the test.

(1) *Retesting.*

In September, 1922, 116 pupils of the University High School, University of Minnesota, were retested with the same test. The majority of these pupils were beginning sophomores who had finished General Science the preceding June, a small number were freshmen who had been tested on the preceding June 10th as eighth grade pupils, and the remainder were juniors and seniors in science classes.

For the purpose of ascertaining the stability of the achievement as shown by one testing, the results of the second test were compared with those of the first test given the preceding June. Since the first test had been given at the very end of the school year, and the second test had been given at the

beginning of the following school year, with only three months of vacation intervening, it would seem that rather ideal conditions were secured for establishing the reliability of the measuring instrument used. The three months of vacation were sufficient to allow the pupil to forget enough of the details of the test taken in June to make the scores secured in September fair measures of the pupil's achievement at that particular time. At the same time, the three intervening vacation months added little to the pupil's fund of General Science information, other than that which he had gained by simply living three consecutive months outside of the schoolroom.

When the first and second test papers were examined, it was found that while all the 116 retest papers were completed, among the June tests there were only 75 papers in which all 300 items had been marked, and 41 papers in which only the first three pages, or 221 items or a little more, were marked. Therefore it was deemed advisable first to compare the 75 completed papers with their 75 completed retests, and then to rescore the whole 116 papers on the basis of the first 221 items and compare those 116 scores with the retests for reliability.

Both in the complete test and in the 221 item test correlations with retests were very high, as can be noted.

	No. pupils	*Sigma* 1*	*Sigma* 2†	*r*	*P. E.*
Complete test	75	42.7	36.0	.877	.02
221 item test	116	35.6	28.0	.82	.02
Mean				.85 (.847)	

* Standard deviation on first test.
† Standard deviation on retest.

These coefficients of correlation would indicate that the ability of the original General Science test to differentiate among pupils was fairly constant; that is, a pupil who scored high on the first test would also score high on the second test, and a pupil who scored low on the first test would consistently score low on the second test. On account of the narrow range of the group tested, however, the correlations of .82 and .88 (.877)—mean .85—are relatively high.

(2) *Permanency or stability of the pupils' correct and incorrect responses.*

The papers of the 116 University High School pupils who had been retested were again examined for the purpose of

determining whether a pupil's responses to particular items in June and in September showed variation. In other words, how permanent were the responses made in June to the various items?

It is conceivable, *while not probable,* that a pupil taking a 300 item test in June and making a score 150, a score of 50% right, on taking the same test in September might again make a score of 150 or 50% right. It is further conceivable that an examination of the actual items failed the first time and items failed the second time might show a variation from a condition where the same 150 items were right in each trial to a condition where no item of the 150 originally correct was correct the second time. In either case a correlation between first and second scores would be 1.00, whereas the reliability of the items would be zero. As a measure of the relative amount of achievement such a condition might be satisfactory, for it gave the same total score each time, but as an indicator of the kind of material on which the pupil failed such a condition would be highly unsatisfactory. It is to be understood that the above assumptions are only theoretical possibilities, and not what was even probable.

In the present study it was ascertained what per cent of each of the 116 pupils' responses were identical in the two tests and what percent varied. This was done by taking note of all the individual errors made on the second test and all the individual errors made on the first test, and then comparing the two sets to find out which errors were made both times and which errors were made only once.

Results showed that with the exception of a small percent the responses were uniform in both trials. In other words, an item correctly marked in June would be correctly marked in September, and an item incorrectly marked in June would be incorrectly marked in September. The actual percents of pupils' responses in two trials which were not identical ranged *from* 1.9% *to* 8.2%—*median* 4.35%. Inasmuch as the scores made on the two tests varied from 57 to 256, or the number of "wrongs" varied from 243 to 46, it would seem that this 4.35% represents the median number of variations due to guessing. Underlining of the correct response twice at intervals of three months, when there are five possible responses, could not be attributed to pure guess. In short, the stability

of the items, or their tendency to secure from the pupil the same response, whether it be right or wrong, was such that uniform responses amount to over 95% of the 300 items of the General Science test. The P. E. of estimate, based on retest correlation, using the formula "P. E. of estimate equals the P. E. times square root of 1 — r square,"[1] was 9 points. In other words, if an infinite number of trials were given the true scores made by pupils would not, in 50% of the trials, differ by more than 9 points from the score obtained at the first trial.

(3) *High positive correlation with other criteria.*

By retesting pupils with the 300 item General Science test it was ascertained that the test had a tendency to give individual pupils relatively the same ranking on its second presentation as it did on its first. In other words, the measurements of the original 300 item test resembled measurements of a steel ruler as much as is indicated by a positive correlation of .85 between two measurements. It was further ascertained that this positive correlation of .85 was made by identical responses to over 95% of the items. Just as the retest results showed that the test as a whole possessed a fair amount of reliability, the counting of actual errors on each item showed the individual items to be very reliable. A test, however, might be reliable as a whole and also reliable in its parts and still be no measure of achievement in General Science. That is, a test might always give the same measurements, but the measurements might have no relationship to the achievement in the subject it was supposed to measure.

To make certain that the original test was a measure of achievement in General Science, it was correlated with other criteria which are known to have some validity as measures of General Science achievement. For instance, General Science achievement is in part dependent on intelligence. Studies of the relationship between marks in school subjects and scores in standard intelligence tests show positive correlations ranging from about .30 to .70. That these correlations are not higher is usually explained by the fact that all pupils do not achieve in proportion to their native ability because of the influence of other factors, such as industry, interest, and so

1 P. E. est. = P. E. dist. $\sqrt{1-r^2}$

forth. Further, if pupils did achieve in proportion to their native ability, there would still be many variations, since studies of school marks have shown certain inherent weaknesses in marks given by teachers. When, however, scores in standardized achievement tests of school subjects are correlated with scores in intelligence tests, the result, while a little better, is still far from a perfect correlation. A positive correlation between achievement test and mental test scores as low as .50 is quite usual.

Scores made by these University High School pupils in the Miller Mental Ability Test were available. For the juniors an average of five mental tests, given in the freshman year, were available. When achievement in the 300 item General Science test was correlated with mental test scores, the following results were secured:

Correlation between	*Grade*	*Pearson r*	*P. E.*	*No. cases*
1. Miller Mental Test scores and 300 item General Science test scores	8	.70	.055	39
	9	.43	.116	20
	10	.585	.07	31
	11	.73	.067	26
	12	.501	.08	38
2. Miller Mental Test scores and 221 item General Science test scores	8	.61	.06	52
	9	.47	.09	34
	10	.41	.075	56
	11	.483	.085	36
	12	.45	.08	45
3. Mental Ages in months and 300 item General Science test scores.	8	.67	.06	38
4. Mental Ages in months and 221 item General Science test scores.	8	.642	.054	52
5. Intelligence Quotients and 300 item General Science Test Scores	8	.573	.072	39
	9	.43	.106	27
	11	.64	.098	15
	12	.54	.075	38
6. Intelligence Quotients and 221 item General Science test scores	8	.576	.062	52
	9	.43	.075	54
	11	.62	.09	20
	12	.494	.075	45
7. Ave. Five Mental Tests and 300 item General Science test scores.	11	.61	.09	18
8. Ave. Five Mental Tests and 221 item General Science test scores.	11	.48	.08	40

Examination of the figures shows that when the achievement on the whole 300 item test was correlated with intelligence, the relationship was relatively high. When the achievement on the first three pages of the test (221 items) was used, the relationship was also uniformly high, and even slightly more valid because of the larger number of cases involved.

Examination of the pupils' achievement in General Science, as indicated (a) by marks in General Science, and (b) by an average of marks in all subjects, and (c) in the case of seniors also of honor points,* the latter two being criteria of general scholarship, also showed a decided degree of positive relationship. In the case of the eighth grade pupils, who had taken the General Science test on June 10th as a part of their preliminary examination before entering the University High School, the scores on the General Science test and only the first two quarters' marks were considered. Therefore, the correlation for these pupils indicated the degree with which the original test gave an accurate prognosis of what marks teachers would give those pupils after they had taken the course in General Science. In the case of the 9th, 10th, 11th and 12th grade pupils, all of whom had taken General Science in the 9th grade, the correlation is between the average marks earned in their freshman year in General Science and the achievement in the General Science test taken June 1st, 1922. In the case of 12th grade pupils, their contact with General Science as a subject was three years removed.

Correlation between	*Grade*	*Pearson r*	*P. E.*	*No. cases*
1. General Science marks and 300 item General Science test scores	8	.61	.065	39
	9	.835	.039	28
	10	.76	.05	30
	11	.47	.11	22
2. General Science marks and 221 item General Science test scores	8	.62	.057	52
	9	.60	.059	54
	10	.64	.055	54
	11	.44	.10	29
3. Percentile Rank, 1st year's marks and 300 item General Science test scores.	10	.59	.10	19
4. Percentile Rank, 1st year's marks and 221 item General Science test scores.	10	.43	.085	40

* Numerical basis for awarding scholarship honors.

5. Honor Points and 300 item General Science test scores	12	.40	.09	38
6. Honor Points and 221 item General Science test scores	12	.46	.08	45

(4) *Correlation between a part and the whole of the test.*

In the case of the University High School pupils, data were available for 164 pupils whose papers were evaluated both on the basis of their achievement on 300 items of the General Science test and on the basis of their achievement on the first 221 items of the General Science test. In a later part of this study comparisons were made on the basis of the first three pages of the test only. Justification for doing so is to be found in results of this study of University High School pupils on the 300 and 221 item bases. For instance, when the results of the 300 and 221 item General Science test of a group consisting of from 26 to 40 pupils were correlated by the rank order method, the correlation was practically perfect. When the achievement on a part and on the whole of the General Science test was correlated by the product-moment method, the results, while not perfect, were very close to 1.00, as can be noted in the following figures:

Correlation between	*Grade*	*Pearson r*	*P. E.*	*No. cases*
300 item General Science test scores and 221 item General Science test scores.	8	.97	.003	40
	9	.90	.025	28
	10	.99	.002	31
	11	.996	.001	26
	12	.995	.001	39

It is evident that for the purposes of group comparison, the first three pages of the General Science test gave practically as accurate relative results as did the whole test. This was due to the fact that the items, as arranged in the original test, were placed in absolutely random order.

In resumè it may be said that the original General Science test as a measure of achievement and information in General Science was a reasonably reliable measure. Its self-correlation by a retest of 116 pupils was .85. Identical responses after three months equalled 95% of all responses made by a pupil on two trials. There were high correlations between the test scores and known criteria of General Science. Correlations between a part and the whole of the test were .90 to .996. Hence the preliminary 300 item General Science test was considered satisfactorily reliable.

CHAPTER VI.

DEVELOPMENT OF THE GENERAL SCIENCE SCALE.

In the preceding chapter it was shown that the original 300 item General Science test was fairly reliable. In fact, the test proved more reliable when compared with certain known criteria than are some achievement tests for various school subjects which have been standardized and placed on the market today.[1]

It might have been possible, on the basis of the large number of pupils for whom data were available, to establish norms and to use the test in its crude form. It had, however, certain inherent faults,—faults which are bound to occur in every test of its kind. In the first place, in order to be inclusive, the test had 300 items. That number of items makes the test too long to administer satisfactorily. The median time required for this test, computed on 600 cases, was fifty-nine minutes, with a range of thirty-five to one hundred and ten minutes and a quartile deviation of eleven minutes. Besides the fact that the test took longer than the average pupil is able to maintain interested effort, the work of scoring and recording of results was decidedly laborious. Efficiency in giving requires a shorter test and one which is also easier to score. Further, some of the items in the original test turned out to be decidedly valueless.

In the original test it was possible to find class, grade, and school medians, but, unless one entered into statistical procedure to ascertain the fact, it was impossible to tell whether a difference of twelve items between two medians was a real difference or due to chance. This fact, when ascertained, was, however, still open to the question of quantity. How much of a difference is a difference of twelve items on the original test? A study of data presented later will show that this difference of twelve items might mean a difference due to chance and therefore negligible when occurring in one part of the scale, or it might easily represent the difference between the median and the seventy-fifth percentile of an age group when occurring in another part of the scale. A study of the value of individual items, which appears later, also shows

1 Henmon, V. A. C. "Some limitations of educational tests." Jr. of Ed. Research, Vol. VII, No. 3, March, 1923, pp. 185-198.

that succeeding in twelve items in one part of the scale might represent very little ability, whereas succeeding in twelve items in another part of the scale would represent ability of practically genius type.

The original General Science test contained enough material which, if properly evaluated and arranged, would make a General Science Scale composed of three Forms of known difficulty, which could be used interchangeably, with long or short periods intervening, for purposes of checking up progress of teaching and accuracy of testing. To be sure, if a test with a smaller number of items were to be used, in order to secure as accurate results as those secured by the 300 items, the lesser number of items would necessarily have to be accurately selected and evaluated. Moreover, as stated before, in the 300 item test it was possible, owing to the large number of items of more or less equal difficulty, for two boys to achieve equal scores up to 150 items each and still leave no single item which had been done correctly by both of them or failed by both of them. From the standpoint of diagnostic quality this was a decided weakness, the remedy for which was the development of three standardized Forms of the General Science Scale, with each Form of known difficulty.

Furthermore, were the original General Science test used, because of varying difficulties of the different items the various items represented various amounts of achievement. That is, the 300 item test represented a measuring tape with 300 units, very few of which were of equal length (difficulty). Succeeding in five items in one part of the scale was not equal to succeeding in five items in another part of the scale. These facts, besides being annoying in the interpretation of results, would be unknown to many persons using the test; hence the necessity for developing scale Forms of known difficulty from the items at hand.

There are at least three methods possible for developing a scale from a set of unselected items. The first of these methods is well characterized by the English Composition Scale developed by Dr. Van Wagenen.[1] In the construction of this Scale Dr. Van Wagenen had English compositions on the subject, "How I earned some money," rated by numbers of competent

1 Von Wagenen, M. J. English Composition Scale. World Book Co.

judges on Structure, Mechanics, and Thought Content. The compositions were rated by judges by placing them in order of merit on the basis of each of these three criteria. The unit of measurement was the P. E. of difference of judgment. A composition rated superior to another composition by 25% more of the judges than the latter was given a rating of 1 P. E. superiority over that composition. Two compositions regarding whose superiority the judges were equally divided were rated as equal. It is evident, however, that starting with original compositions, the ultimate values, while obtained by a thoroughly reliable method, would show various unequal intervals between individual compositions in the scale. This scale represents a steel tape in which all lengths are known and marked, but, instead of starting always at the end of one unit and at the beginning of the other, like 1, 2, 3 inches, etc., it was divided thus: 1, 3½, 3¾, 7 inches, etc. inches at the distances so indicated. In using this Scale the composition to be graded is first compared with the different compositions in the Scale whose values are known. While a scale of this form has certain merits, it did not seem feasible for a General Science scale.

Another method of scale development is that used by Woody in the development of the Woody Arithmetic Scale.[2] This method has also been used by Trabue in the Language Completion Scale,[3] and by Posey and Van Wagenen in the development of their Geography Scale.[4] In this method the unit is the difference of difficulty of an item which will cause the correct responses to that item to vary one-tenth of a P. E. in a normal surface of frequency from the item one unit easier or more difficult. Since this method was adopted for use in the development of the General Science Scale, its description will be left to be given in detail for the various steps in the construction of the Scale.

A third method of scale construction consists in taking a number of questions not necessarily related to fundamental

2 Woody, Clifford. "Measurements of some achievements in arithmetic." Teachers College, Columbia University. Contributions to Education, No. 80, 1916, pp. 1-63.

3 Trabue, Marion R., "Completion-Test Language Scales." Teachers College, Columbia University. Contributions to Education, No. 77, 1916.

4 Posey-Van Wagenen, "Geography Scales." Public School Publishing Company, Bloomington, Illinois.

elements of a given subject, giving them to a considerable number of pupils who have just completed the subject, and ascertaining for each question the number of pupils who succeeded in each question and who were rated "A," the number who succeeded in each question and who were rated "B," and so forth. Using this method the ability of the question to differentiate among pupils of varying abilities—its diagnostic ability—is ascertained. A scale is then made up of a number of such questions which combined are able to differentiate among those pupils who receive grades of "A," "B," C," etc. Such a diagnostic test method was used in some of the army trade tests during the war. For instance, where questions were selected to differentiate between an expert carpenter and a journeyman carpenter or an ordinary laborer who desired to become a carpenter, oftentimes questions which had little to do with the actual work of the carpenter but which could only be answered by the expert were used to differentiate different levels of trade ability.

A method of scale construction similar to this third method, if used for a General Science scale, would be dependent for its accuracy on the accuracy of the marks given in General Science. In view of recent studies of the unreliability of school marks, this method would be far less accurate than the method which has been employed. For some purposes it seems that while both the first and third methods described, being the only methods available for certain subjects, are more satisfactory than no method at all, they carry the weakness which is inherent in dealing with an unknown from the standpoint of another unknown. The second method described was adopted for the General Science Scale because there are at least two things certain, namely, that (a) the questions or items selected are from the subject to be measured and can be rated right or wrong, and (b) it is possible to ascertain what percent of any particular group or classification of pupils can do each item correctly.

Derivation of the Scale.

When the 300 item test for each pupil had been scored, the test papers were divided according to the classification previously described, namely, according to grade, sex, and whether

or not the pupil had taken General Science. This made in all twenty classifications.

When the scores were tabulated for each group, it was evident that an arrangement of the groups was possible which showed a gradual increase of median group scores with age and training. Thus —8G (8th grade girls without General Science training) made the lowest class or group median score, while +12B (12th grade boys with General Science training) made the highest group median score. Throughout, the boys were superior to the girls when similar groups are compared, pupils having taken General Science were superior to those who had not taken the subject, and pupils of an upper grade were superior in their achievement on the test to those of a lower grade. These facts pertain only when group medians are compared. As a matter of fact there was tremendous overlapping of group scores. For instance, an 8th and a 9th grade girl made scores of 25. Two —8G made scores of 182 and 184, or scores so high that they exceed anywhere from 40 to 95% of all the grade groups, even the +12B group whose median was 190. An 8th grade girl who had not studied General Science did better on the test than did 40% of 12th grade boys who had studied the subject.

Inasmuch as General Science is almost universally a 9th grade or freshman subject in four-year high schools, and an 8th grade subject in junior high schools, it was deemed satisfactory to take for the purpose of standardizing the items for the different Scale Forms (a) the 500 —8G and the 400 —8B, and (b) 430 +9G and the 430 +9B. (Actually there were 437 +9G who had turned in completed papers). All of these pupils had turned in papers in which all of the 300 items had been marked.

It should be explained that the use of 900 eighth grade pupils who had not had General Science for the purpose of standardizing a General Science Scale, while not at first self-explanatory, will become clear when it is considered that (a) the Scale was intended as a diagnostic test, (b) even with —8th grade pupils a considerable percentage exceeded the median achievement for +9th grade pupils, and (c) a pupil's success in General Science is to a certain extent quite as much dependent on what he knows before entering the course as it is on what he learns in the course.

The unit of measurement in this Scale was to be that difference of difficulty of items which would cause the correct responses to any item to differ one-tenth of a P. E. (.1 P. E.) on a normal surface of frequency from the items one unit more easy or more difficult. The next problem, therefore, was to reduce the difficulty of all items to P. E. values.

Having selected the four groups which were to form the basis for the valuation of items, responses for the total of 1760 papers were tabulated so as to secure the number in each group that made correct responses to item 1, the number that made correct responses to item 2, and so on.

The number of pupils in each group was found to be large enough to insure the stability of the item placement. This was done by dividing each of the four groups into two parts when counting the number of correct responses, treating the first part as one distribution and the whole group as another distribution. The rank order of each item of the 300 was then determined, first on the basis of the first part, and then again on the basis of the whole group. The rank order correlation between the difficulty for a part and the difficulty for the whole group in each case was over .98. Correlation between frequency of correct responses for each item computed for

(a)	350	—8G	and	500	—8G	gave	coefficient of	.9964
(b)	300	—8B	and	400	—8B	gave	coefficient of	.9968
(c)	215	+9G	and	400	+9G	gave	coefficient of	.981
(d)	215	+9B	and	430	+9B	gave	coefficient of	.984

The significance of these figures is clear, namely, that for most purposes had the selection of data stopped with the 350 —8G, the 300 —8B, the 215 —9G, and the 215 —9B, the order of difficulty would not have changed enough to have made any appreciable difference, as the P. E. of R with such high coefficients and large numbers of cases is negligible.

Further, combination of these four groups of data into a composite source of data for the Scale is not as lacking of homogeneity as would be indicated by the fact that pupils who have not had and pupils who have had General Science were used to standardize a General Science Scale. In a later table ("Percentile Scores on 300 items made by 6053 cases") the medians for these four groups are 114, 127, 150 and 162 respectively. An examination of the medians might indicate considerable dispersion of results. Examination of the fol-

lowing data, however, shows that while the +9B whose median was 162, did as a group 48 items more than the —8G whose median was 114, the order of difficulty of items for all four groups was relatively similar. This is indicated by the fact that the rank order correlation of the frequency of correct responses for the different items computed for

(a)	500 —8G and for 430 +9G was .87	with a P. E. of	.007
(b)	400 —8B and for 430 +9B was .916	with a P. E. of	.005
(c)	500 —8G and for 400 —8B was .95	with a P. E. of	.003
(d)	430 +9G and for 430 +9B was .91	with a P. E. of	.005
Mean	..... .912	.....	.005

Reduction of frequencies of correct responses to percentages.

Having the number of times each item was done correctly by each of the four groups selected, the next step was to convert each of the frequencies into percent of the total group and into the P. E. value for that group. Thus one item (number 78) was answered correctly by 14 "—8G", 46 "—8B", 75 "+9G", and 122 "+9B." Since there were 500 "—8G", 400 "—9B", 430 "+9G" and 430 "+9B" in all, the fourteen correct responses for the 500 "—8G" equal 2.8% of correct responses, the 46 "—8B" equal 11.5% correct responses for that group, and the 75 and 122 are equivalent to 17.4% and 28.4% of correct responses for the "+9G" and "+9B" respectively. Similarly for each item, the frequency of correct responses for each of the four groups was reduced to percentages. This enabled the comparison on the same basis of the difficulty of each item for the different groups.

Reduction of percents of correct responses to percent of deviation from median.

Inasmuch as the unit of measure adopted was the P. E. from the median, the percents of correct responses were next converted into P. E. values from the median. For this purpose it was found convenient to use the Table of P. E. Values given by Woody.[5] In this table are given the P. E. values corresponding to given percents of the normal surface of frequency, percents being taken from the median. It was therefore necessary to ascertain for the percent of each item the

5 Woody, C., "Measurements of some achievements in arithmetic," p. 37, Table X ("taken directly from B. R. Buckingham's Spelling Ability, Table XLVII. It is a modification of the table given in E. L. Thorndike's Mental and Social Measurements, page 200").

percent of deviation from the median, or fifty percentile point, which the percent of correct responses represented. As stated in the preceding paragraph, 14 correct responses for item 78 on the part of the 500 —8G represents 2.8% of correct responses. Two and eight-tenths percent, however, is 47.2% below the median (50%—2.8%). Forty-six correct responses on the part of the 400 —8B represented 11.5% of correct responses, which was in turn 38.5% below the median (50% —11.5%). The 75 correct responses on the part of the 430 —9G represented 17.4% correct responses, which was 32.6% below the median, while the 122 correct responses on the part of the 430 —9B represented 28.4% correct responses, which was 21.6% below the median. Similarly the percents of correct responses on each item for each group were reduced to percents of deviations from the median. Percentages of correct responses below 50% gave deviations which were indicated as minus (—) deviations; percentages over 50% gave plus (+) deviations. Items with minus (—) deviations being answered correctly by less than 50% of the group were "difficult"; items with plus (+) deviations were answered correctly by more than 50% of the pupils and were therefore "easy." To be answered by 50% of the group would cause an item to be considered of average or median difficulty for that group.

Reduction of percents of deviation from median to P. E. from median.

To convert the deviations from the median was a matter of looking up in the P. E. Table each of the deviations from the median. Thus, 47.2% below the median is equivalent to 2.834 P. E. below the median and is indicated by —2.834 P. E. —38.5% is equivalent to —1.780 P. E. from the median. —32.6% is equivalent to —1.391 P. E. from the median. —21.6% is equivalent to —.847 P. E. from the median. Therefore there were four columns of P. E. values which represented the P. E. value of each of the percents of deviation from the median of correct responses for each group for each item. The direction from the median is indicated by positive and negative P. E.'s.

Examination of the P. E. values for item 78, the first item considered, shows that for the four groups selected this item

had P. E. values of —2.834, —1.780, —1.391, and —.847. It is evident that this item was not of equal difficulty for each of the four groups, since it has been seen that the percent of correct responses for the four groups ranged from 2.8% to 28.4%. A similar condition is found for each of the succeeding items. For instance, item 27 has P. E. values of —2.746, —2.439, —2.397, and —2.245 for the four groups. Obviously each item has four P. E. values instead of one, and unless some method of equating these P. E. values be found, four separate scales—one for each of the four groups—would be necessary. If eight different groups were to be measured and the same conditions were true, eight scales would be necessary, and so on. That being nearly impossible a method of equating the figures was devised.

Computation of average P. E. difference between groups.

This apparently confused state of affairs was easily adjusted. The mean P. E. difference on all 300 items between each of the groups was ascertained, then, using this mean P. E. difference, each of the groups was converted to the level of the lowest group. Thus the difference between the P. E. value of item 78 for —8B (—1.780) and the P. E. value of item 78 for —8G (—2.834) is 1.054 P. E. Since a greater number of the —8B did item 78 correctly than did the —8G this difference is positive. The P. E. difference on item 27 for —8B and —8G is (2.439 — —2.846) or .307 P. E. This process was repeated for each of the 300 items and algebraic sum of all the P. E. differences for the 300 items for "—8G" and "—8B" was 49.295. This sum divided by 300, the number of P. E. differences, gives a mean P. E. difference of .164. In other words, on 300 items the P. E. values of the correct responses of the 400 —8B exceeded the P. E. values of the correct responses of the 500 —8G by .164 P. E.

In the same way the P. E. differences between the P. E. values of the —9G and the —8B were computed. The algebraic sum of all the P. E. differences between "+9G" and "—8B" was 124.308. This number divided by 300 gives an average P. E. difference of .414, or the amount in P. E. by which the responses of the 430 +9G were superior in accuracy to those of the 400 —8B.

In the same way the differences between the P. E. values on each item of the +9G, and the P. E. values on the same items for the +9B were computed and the mean of .086 found, which is the amount in P. E. by which the +9B are superior to the +9G on these items.

The computation of the mean P. E. differences between the different groups has shown in P. E. amounts what would be evident from the examination either of the individual number or of the percent of correct responses made by each group on each item, namely, that from the standpoint of achievement in the General Science test the "—8G" (8th grade girls who have not had General Science) group is the lowest, the —8B group the next higher, and +9G next, and the +9B group is the highest of all four groups. The advantage, however, of these results is that this difference in achievement among the four groups is given in P. E. amounts. It can be said, therefore, that the —8B are .164 P. E. superior to the —8G, that the +9G are .414 P. E. superior to the —8B, and that the +9B are .086 P. E. superior to the +9G.

Reduction of all scores to the eighth grade level.

In order to have the items all evaluated to an average P. E. value, the next step was to reduce the achievement of each group on each item to a common level. The necessity of this procedure can be easily illustrated by the following hypothetical case. Suppose A, B, C, and D were each given a tape-measure in which the units were all of uniform length,—inches in the case of the tape measure, P. E. amounts in the case of this test. But suppose that A's tape-measure began with the inches numbered at 0, B's tape-measure had 164 inches torn off, C's tape-measure had 414 inches more torn off than had B's, that is, 414 plus 164 inches or 578 inches torn off, while C's tape-measure had 86 inches more torn off than had C's, that is, 164 plus 414 plus 86, or 664 inches torn off. Suppose that all four measured a certain distance. Let us assume that this distance was 1,000 inches. If each began with his tape as it was numbered and took the reading at the farther end on his tape, it is obvious that A's reading would be 1,000 inches, since the divisions on his tape were numbered beginning with zero. It would further be obvious that the reading on B's tape would be 1164 inches, since the

numbers on his tape began with 164. Likewise C's and D's readings would be 1578 and 1664 inches respectively, because their tapes began with the numbers 578 and 664. Any mean evaluation which these four individuals might make of the distance measured would first require that the four readings be reduced to a common basis. This could be accomplished by reducing the readings to the level of any one of the four individuals, that is, reduced to A's readings by subtracting 164, 578 and 664 from B's, C's and D's readings respectively. Or, readings could be reduced to B's reading by adding 164 to A's reading and subtracting 414 and 500 (414 plus 86) from C's and D's readings respectively. In the same way the readings could be reduced to the level of C or of D. Once the readings were reduced to a common level, an average obtained, and account taken of the zero point, then the four readings on the four tapes, each of which began with a different number, would give a measure as reliable as would measurement with a steel tape in which the units began with zero.

In the case of the General Science Scale it was decided to reduce the P. E. values made by each group to the level of the 8th grade girls without General Science. To do so it was necessary to subtract .164, the mean P. E. difference between —8G and —8B, from each of the P. E. values given for —8B, .78, the sum of the P. E. difference between —8G and —8B or .164 plus the P. E. difference between —8B and +9G or 414, from the P. E. values given for +9G and .664, the sum of the P. E. difference between —8G and —8B or .164 plus the P. T. difference between —8B and +9G or .414 plus the P. E. difference between +9G and +9B or .086 from the P. E. values given for +9B. For item 78 the four P. E. values of —2.834 for —8G, —1.780 for —8B, —1.391 for +9G and —.847 for +9B become, respectively, —2.834, —1.944 (—1.780—.164=—1.944), —1.969(—1.391—.164 —.414=—1.969) and —1.511(—.847—.164—.414—.086= —1.511). In this way "P. E. Values" for each of the groups were computed in each case from a common point, namely the median of the 8th grade girls without General Science.

Weighted average P. E. Value.

Having the P. E. values for each item in comparable form, that is, all computed from the same basis, the next step was

to ascertain the average value of these four measures. Thus, for item 78, the "P. E. Values" are —2.834 P. E., —1.944 P. E., —1.969 P. E., and —1.511 P. E. made by the four different groups. It is evident that a simple arithmetical mean of these four P. E. values might be used. It was thought advisable, however, to weight these values in the order of their reliability. That is, P. E. values are most accurate in the middle fifty percent of a distribution one P. E. on each side of the median, less accurate 2 P. T. away, still less accurate 3 P. E. away, and more so when 4 P. E. away from the median. Therefore, in computing the average P. E. value of each item it was decided to use a multiplcation factor of 10 for values between 0 and 1 P. E., of 6 for values between 1 and 2 P. E., of 3 for values between 2 and 3 P. E., and of 1 for values between 3 and 4 P. E. In each case the actual P. E. value of the item, not its recomputed value, was used to find the multiplication factor. To illustrate, for item 78 the final, weighted average P. E. Value was computed as follows:

—2.834 x 3	(2.834 is between 2 and 3)	equals	— 8.502
—1.944 x 6	(1.780 is between 1 and 2)	equals	—11.664
—1.969 x 6	(1.391 is between 1 and 2)	equals	—11.664
—1.511 x10	(0.847 is between 0 and 1)	equals	—15.110
Total Wts. 25		Total	—47.090

—47.090 divided by 25 equals —1.884, or the final weighted average value of item 78 computed from the median of the —8G group. In like manner each of the 300 items were weighted and averaged to secure the final weighted average Value from the median of the —8G group found in column 20. Where items near the middle of the scale had both positive and negative values, the total in the above computation was the algebraic sum of the plus and minus values.

Location of the value of each item with reference to the arbitrary zero.

Thus far a final average P. E. value has been secured for each item. This value, however, is merely a relative value in uniform units computed from the median of the 8th grade girls without General Science. It is apparent that even the lowest 8th grade girl, who made a score of between 25 and 29, did not represent zero ability in achievement on this test.

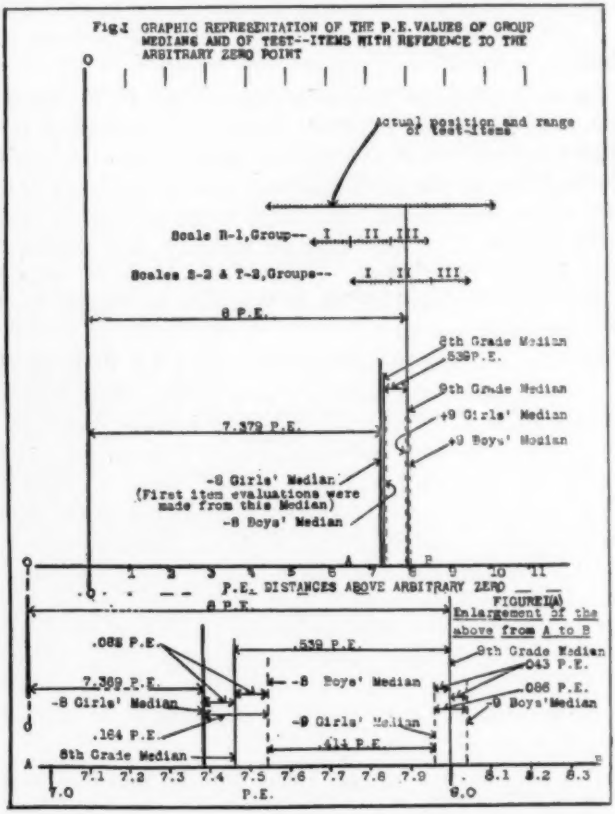
Were there a hypothetical case of an 8th grade girl who had made a zero score on this test, it would still be doubtful whether or not her achievement or ability in General Science was zero, for, were there an item easier than the easiest item on the test, it is quite conceivable that she might have marked it successfully.

Zero, or better yet a score of 1 item or one-fifth of one percent on the table of frequencies of a normal surface of distribution would represent a deviation from the median of —49.8% or a P. E. value of —4.275. This, however, is an unknown distance or value above zero. Since the zero is unknown, it was thought advisable arbitrarily to select a zero point sufficiently low to include for all practical purposes every possible achievement or ability in General Science. It was therefore decided to make this arbitrary zero point 8 P. E. below the median achievement of 860 individuals who had taken General Science for one year. Since both boys and girls had taken General Science and the median achievements of the two groups in the 9th grade varied by .086 P. E., this zero point is 8 P. E. below a point which is one-half of .086 P. E. or .043 P. E. above the median achievement of the plus 9 Girls and .043 P. E. below the median achievement of the plus 9 boys. This zero point is also .043 plus .414 plus .164 or .621 P. E. above the median of the —8th grade girls who were taken as the basis for computing the P. E. value of each item.

It is obvious, then, that in order to compute the actual value in P. E. of each item above the arbitrary zero point, it would be necessary to bear in mind that the average P. E. value already computed is computed from the —8 Girls' median, and that this median is .621 P. E. below the point which is 8 P. E. above the arbitrary zero point. In other words, the —8 Girls' median is 8.000—.621 P. E. or 7.379 P. E. above the arbitrary zero point. To secure the actual P. E. value of each item above its zero point it was necessary to recompute the average P. E. value, bearing in mind that the —8 Girls' median is the point of reference for the average value and that this point of reference is 7.379 P. E. above the zero point. On this basis the difficulty of each item was finally computed.

In this computation an item which is below the median, that is, has a minus P. E. value as does item 78, is an item

which was very hard since it was done successfully by less than 50% of the pupils. An item having a negative P. E. value is then above the median difficulty. Therefore, while item 78 was done successfully by an average number of pupils equivalent to an average P. E. value of —1.884, the difficulty of item 78 was really 1.884 above the —8 Girls' median and



its actual P. E. value was 7.379 plus 1.884, or 9.263 P. E. above the zero point. Likewise item 27, which had an average P. E. value of —2.808 from the 8th grade girls' median, had an average difficulty which gives it a value of 7.369 plus 2.808 P. E. or 10.187 P. E. above the zero point. Item 148, on the other hand, was so easy that enough pupils, an average

of about 96%, did it successfully to give it an average P. E. value of positive 2.570. This item, therefore, was extremely easy. Its difficulty was really 2.570 P. E. below the 8th grade girls' median and its final value was 7.369 —2.570 P. E. or 4.809 P. E. above the zero point. In like manner all 300 items were given a final P. E. value above the zero point in column 21 by adding the P. E. value, if negative, to 7.369 and subtracting the P. E. value, if positive, from 7.369.

Figure I (*Graphic Representation of the P. E. Values of Group Medians and of Test Items with Reference to the Arbitrary Zero Point*) is a graphic representation of the relative positions of the grade medians and of the range of difficulty of items in the test. Reference to the two figures (Figure I and Figure IA) may help to simplify any obscurity in the preceding description. It should be borne in mind that Figure IA is a magnification of that part on Figure I which lies between A and B.

The range of the items was from about 4.5 P. E. to about 10.2 P. E. above the arbitrary zero point. Naturally some uniform unit of difficulty should exist between items on the scale, just as uniform inches exist on a footrule even if each end of the footrule has a part cut off from it. The unit which was selected as comparable to the inches on the footrule was one-tenth of one P. E. (.1 P. E.). Therefore the P. E. values above the zero point have been immediately converted into one-tenth P. E. values. Thus item 78, which has a value of 9.263 P. E., is written as having a value of 92.63 points of one-tenth P. E. each above the zero point. Item 27, which has a P. E. value of 10.187 above the zero point, is written as having a value of 101.87 points of one-tenth P. E. each above the arbitrary zero point.

It is obvious that several items will be found at each .1 P. E. level of difficulty if the 300 items range between 4.5 P. E. and 10.2 P. E. or between 45 and 102 one-tenth P. E. points, in other words over a range of 5.7 P. E. or 57 one-tenth P. E. points. Table II (*Difficulty of the 300 Items in the General Test Figured from the Selected and Defined Arbitrary Zero Point*) gives the original item numbers which represent the actual items as they appeared in the original

General Science test and which occur at each one-tenth P. E. level of difficulty. With Table II in hand, all that remained to make up any scale or duplicate scale forms was to decide on the kind of items and the ranges of items to appear in each scale. The items actually used in the completed scales are indicated by the columns to the left and below the line separating the item numbers.

Selection of Scale Items.

A survey of items, of the ranges of difficulty, and of the number of items at each level of difficulty showed that three forms of known value could be constructed. Having in mind a method of computing scale scores, which will be described later, it was decided to construct a Scale having three Forms, each of which was composed of three groups of twenty items each. The range of difficulty of the items in any one group was to be one P. E. or ten points of one tenth P. E. each. This meant that in each group there would be ten levels of difficulty with two items at each level. It also meant that the total range of any one scale would be three P. E. or thirty points of one-tenth P. E.

It was found that the easiest scale Form could begin with items at 5.7 P. E. or 57 points and should end at 8.6 P. E. or 86 points in difficulty. This scale Form, designated by "Form R-1", was divided into three groups of items, having two items at each tenth P. E. level of difficulty and ranging from 57 to 66, 67 to 76, and 77 to 86 points of difficulty in each of the three groups respectively. The other two Forms, designated by "Form S-2" and "Form T-2", are also made up of sixty items each over a range of thirty points or 3 P. E., having two items at each level of difficulty and beginning in both forms with item difficulty 67 and ending with item difficulty 96 and divided into three groups of items ranging from 67 to 76, from 77 to 86 and from 87 to 96 points of difficulty for each of the three groups respectively. Reference to Table II shows the original item numbers which have been used to make up the Scale and the difficulty of each item.

Below is to be found a reproduction of a part of Form R-1 of the resulting Scale. This reproduction shows the form for recording errors and excerpts from the scale content which show some of the items as they appear in the finished Scale.

TABLE II.

Difficulty of the 300 Items in the General Science Test Figured from the Selected and Defined Arbitrary Zero Point.

Difficulty*	Item Numbers			
4.6	24			
4.8	148			
5.2	131			
5.4	3, 122, 145			
5.7	123, 254			
5.8	62, 102	82, 133		
5.9	79, 229			Items with numbers in
6.0	23, 126			this area were discarded
6.1	100, 103	190		
6.2	104, 292	246		
6.3	68, 185	250		
6.4	107, 188	51		
6.5	114, 230	192, 248		
6.6	54, 234	183, 198		
6.7	150, 296	118, 169	168, 221	
6.8	98, 225	1, 275	111, 257	132
6.9	202, 247	48, 295	189, 203	
7.0	120, 161	109, 222	262, 277	
7.1	129, 142	169, 299	129, 142	
7.2	32, 60	156, 297	216, 256	
7.3	113, 240	65, 279	55, 211	
7.4	94, 237	187, 287	59, 172	14, 112, 255, 263
7.5	99, 238	40, 115	96, 20	154, 196, 232, 285, 286
7.6	200, 220	141, 209	119, 184	80, 137, 197, 200, 245, 252, 265, 274
7.7	2, 195	184, 175	8, 71	5, 291
7.8	147, 101	22, 75	30, 176	42, 72, 158, 215, 272
7.9	19, 153	213, 293	31, 160	13, 25, 36, 49, 63, 174, 186, 236, 264, 271, 281
8.0	77, 97	82, 166	93, 199	95, 151, 193, 233, 242
8.1	41, 282	45, 117	162, 21	29, 152, 218, 280, 178
8.2	181, 288	12, 33	266, 268	105, 116, 261
8.3	15, 283	61, 239	26, 167	139, 155, 182, 201, 260, 289
8.4	50, 53	52, 130	37, 226	17, 157, 276
8.5	194, 207	108, 159	136, 165	177, 223, 267, 294
8.6	16, 81	91, 92	170, 284	10, 11, 44, 106, 138, 146, 205, 206, 231
8.7		28, 191	89, 298	46, 47, 56, 73, 85, 171, 210, 227, 243, 249, 270
8.8	R-1	64, 180	86, 212	7, 121, 127, 163, 179, 204, 251, 253, 273
8.9		164, 235	69, 70	4, 259, 300
9.0		219, 290	241, 38	
9.1		43, 208	88, 125	9, 74, 90, 149, 258, 278
9.2		173, 214	18, 224	140
9.3		78, 128	217, 244	
9.4		34, 124	66, 110	
9.5		35, 143	135, 144	67
9.6		6, 134	58, 39	
9.7				
9.8		S-2	T-2	57
10.2				27, 87, 228

* Number of P. E. above zero figure to the nearest tenth (.1).

Note—The three columns above indicate the actual numbers of the items in the original 300 item test which were used in the three Forms of the Scale.

This reproduction is shown through the courtesy of the Public School Publishing Company, Bloomington, Illinois, publishers of the Dvorak General Science Scale.

No. items incorrect	Errors	Scores Corrected (See direction-booklet, p. 5)
Group III	÷2	(Key A) Uncorrected Score.....
Group II	÷2	
Group I	÷2	

Total Errors, Groups I & 11 ....

First Corrected Score ....

Number Errors, Group I (Key B) ....

Final Score ....

No. incorrect....

GROUP I. FORM R-1. (Average value 61.5)

1. A bright, blue sky indicates BAD, FAIR, RAINY, GLOOMY, STORMY WEATHER.
2. The house fly is harmful because it DESTROYS CROPS, HAS A POISONOUS BITE, CARRIES BACTERIA, DESTROYS FOOD, IS HARD TO STRIKE.
3. Balloons float in the air because of their LIGHTNESS, SILVERY COLOR, ENGINES, BASKETS, SIZE.
10. To make milk free from bacteria, milk is PASTEURIZED, FROZEN, INOCULATED, POISONED, SKIMMED.
11. Small pox is prevented by MEDICINE, VACCINATION, ANTI-TOXIN, PASTEURIZATION, STERILIZATION.
19. Milk is tested for the amount contained of BUTTER FAT, WATER, PROTEINS, BUTTER, BUTTERMILK.
20. When air is heated, it CONTRACTS, EXPANDS, FALLS, LIQUIFIES, SOLIDIFIES.

No. incorrect .....

GROUP II. FORM R-1. (Average value 71.5)

21. A kodak is a MOUTH ORGAN, PICTURE TAKING DEVICE, MUSIC BOX, BROWNIE, FILM.

22. The hard substance of the teeth is called DENTINE, ENAMEL, NECK, ROOT, BONE.
30. The kidneys DIGEST FOOD, CLEAN BLOOD OF WASTES, BUILD UP NEW BLOOD CELLS, SUPPORT THE BACKBONE, ARE USELESS.
31. The propelling mechanism of an automobile is termed the CHASSIS, PISTON, DIFFERENTIAL, GOVERNOR, MOTOR.
39. Insects have the following number of pairs of wings: ONE, TWO, THREE, FOUR, FIVE.
40. The average pulse rate for an adult man is 100, 45, 72, 60, 50.

No. incorrect .....

GROUP III. FORM R-1. (Average value 81.5)

41. The process by which animals change their food materials into soluble form is known as ABSORPTION, DIGESTION, PHOTOSYNTHESIS, OSMOSIS, RESPIRATION.
42. The souring of milk is caused by BACTERIA, HEAT, FREEZING, AIR, MOISTURE.
50. Heating systems are placed in the cellar, because heat causes water and air to EVAPORATE, CONTRACT, EXPAND, RISE, FALL.
51. Large buildings are best heated by A PIPELESS FURNACE, HOT AIR, HOT WATER, STEAM, ELECTRIC HEAT.
59. Current is conducted to and from the commutator by MAGNETIC POLES, BRUSHES, FUSES, INSULATORS, SWITCHES.
60. The handle of a skillet becomes hot as a result of RESISTANCE, CONDUCTION, FRICTION, RADIATION, LATENT HEAT.

Scoring of the scale.

The method of evaluating the achievement of any pupil on the General Science Scale is an adaptation of the method worked out by Dr. M. J. Van Wagenen in the Posey-Van Wagenen Geography Scale.[6] This method is based on a sta-

[6] Class Record Sheet for the Posey-Van Wagenen Geography Scales.
Division 2. Information G, L, R, S, T, U, V, or W.
Division 2. Thought R.
The Public School Publishing Co., Bloomington, Illinois.

tistical computation of ten points or sub-divisions per P. E. of a normal surface of frequency. Excepting slight revision, due to the fact that in the General Science Scale there are twenty items for each group whereas in the Posey-Van Wagenen Scale there are ten items in each group, the method designed for the General Science Scale is practically the same as that used in the Posey-Van Wagenen Scale. In the use of this method of scoring, each item is assigned a value of ½. Failure on one item is considered ½ an "error." The total of "Errors" for any group is the number of items failed divided by 2. According to this scheme, a paper in which all the items were wrong would be credited with 10 "errors" in each group, which adapts the items to a ten point per P. E. computation on a normal surface of frequency.

**Securing Pupil's Score.*—To secure the pupil's score is now simply a matter of following specified procedure.

1. The numbers of items incorrect are divided by 2, as indicated on page 1 of the test sheet. The results, including halves, where they occur, are placed under "Errors" on that page. Two items incorrect equal one error.

2. In Key A look up the scale score equivalent of the number of errors in Group III. This is the *Uncorrected Score.* Write it in the space provided for "Uncorrected Score."

3. Add together the number of errors in Groups I and II and place the sum after "Total Errors, Groups I and II." Subtract this sum from the "Uncorrected Score." The result is the "First Corrected Score" and is placed in the space provided for it.

4. It may be desirable to place the number of errors in Group I (number incorrect items÷2) in the space before "Number Errors, Group I." Look up in Key B the correction indicated by the number of errors in Group I and place that correction *after* "(Key B)" and subtract it from the *First Corrected Score.* The result is the *Final Score.*

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* Reprinted from Manual of Descriptions and Directions (Dvorak General Science Scales). Public School Publishing Co., Bloomington, Illinois.

KEY A (For use in obtaining the Uncorrected Score)		KEY B (For use in obtaining the Final Score)	
Errors in Group III	Uncorrected Score	Errors in Group I	Subtract from 1st Corrected Score
½	116	½	0
1	111	1	0
1½	107½	1½	½
2	104½	2	1
2½	102½	2½	1
3	101	3	1½
3½	99½	3½	2
4	98	4	2½
4½	96½	4½	3
5	95	5	3½
5½	94	5½	4
6	93	6	5
6½	92	6½	5
7	91	7	7
7½	90	7½	8½
8	89	8	10
8½	88½	8½	12½
9	87½	9	15
9½	86½	9½	20
10	86		

Sample of Computation of Pupil's Score.—Suppose John Doe had 7 items incorrect in Group I, 12 items incorrect in Group II and 15 items incorrect in Group III. The record on his first page of the test paper would appear as follows:

Scores corrected.....

	Number incorrect	Errors	
Group III	15 ÷ 2 =	7½	(Key A) Uncorrected Score 90
Group II	12 ÷ 2 =	6	Total Errors, Groups I & II 9½
Group I	7 ÷ 2 =	3½	First Corrected Score..... 80½
			Number Errors, Group I, 3½ (Key B) 2
			Final Score.... 78½

Name.....*Doe*,.....*John*.....
(Last name; first name; middle name)

In Group III, 7½ errors, according to Key A, are equivalent to an "Uncorrected Score" of 90 scale points. This is the score a pupil would have who had 15 items incorrect (7½ errors) in Group III and who had no errors in Groups I and II. This pupil would be 10 scale points or 1 P. E. above

the median of 9th-grade pupils who had taken general science one year. 3½ errors from Group 1 and 6 errors from Group II total 9½ errors in Groups I and 11. 90 minus 9½ gives a First Corrected Score of 80½ scale points. This is the score of a pupil who having 7½ errors in Group III, also had 6 errors in Group II and 3½ errors in Group 1, *but who we know would not make any errors if he had to do items still easier than those found in Group I.* Since, however, according to the Gaussian principle (Law of Normal Distribution) a pupil who made 3½ errors (7 incorrect items) in Group I would also make some errors if he had still easier items to do we must correct John Doe's score according to that principle. Naturally a pupil who made more errors in Group 1 would make more errors if he had easier items to do, while one who made fewer errors in Group I would make fewer errors on easier items if he had them to do. Key B shows what corrections ought further to be made to the pupil's score. 3½ errors in Group I in Key B indicate a correction of 2 scale points. 80½ minus 2 equals 78½. 78½ is the Final Score.

INTERPRETATION OF PUPIL'S FINAL SCORE.

Since 80 scale points or 8 P. E. above zero was taken as the median scale score of 9th-grade pupils who had taken general science 9 months (one school year) and since the scale was made to conform to that arbitrary standard, a pupil who gets a final scale score of 80 is doing as well as the median 9th-grade pupil who had taken general science one year. A child who makes a scale score of 75 would be 5 scale points or 0.5 P. E. below the median of the median 9th-grade ability in general science. A child who makes a scale score of 70 would be 10 scale points or 1 P. E. below the median 9th-grade performances. This would mean that at least 75 percent of the 9th-grade pupils could do better than he could. On the other hand, a pupil who made 90 would be 10 scale points or 1 P. E. above the median 9th-grade ability. He would be equalled or exceeded by only 25 percent of 9th-grade pupils who had taken general science one year. Scores of 60 and 100 are 20 points or 2 P. E. below or above the 9th-grade median and are exceeded by 91.1 and 8.9 percent of 9th-grade pupils respectively. A child who like John Doe—the illustration cited—makes a scale score of 78½ points is slightly

(1½ points or .15 P. E.) below median 9th-grade achievement. A study of Key A and of Key B will show that the lowest and highest scores pupils can make are 46½ and 116 respectively. A pupil who made a score of 46½ on Form R-1 would be so deficient that he could not answer with fifty percent correctness items more difficult than the item "A bright blue sky indicates *Fair* weather," while a pupil who made a score of 116 on T-2 or S-2 could answer with fifty percent correctness items at least 2 P. E. more difficult than the item "Water expands when heated above or cooled below 4° C."

In no sense are the scores equivalent to percents of correctness. They mean much more than that. They show the pupils' relative ability to deal with this kind of material, compared with the abilities of thousands of pupils whose test scores were used to standardize these scales. The following table shows some of the percentile ranking of scores between 46 and 116 made by 1700 9th-grade pupils who had taken general science one year.

Score.

46	exceeds lowest	1.1%	of group
50	exceeds lowest	2.1%	of group
55	exceeds lowest	4.6%	of group
60	exceeds lowest	8.9%	of group
65	exceeds lowest	15.6%	of group
70	exceeds lowest	25.0%	of group
75	exceeds lowest	36.8%	of group
80	exceeds lowest	50.0%	of group
85	exceeds lowest	63.2%	of group
90	exceeds lowest	75.0%	of group
95	exceeds lowest	84.4%	of group
100	exceeds lowest	91.1%	of group
105	exceeds lowest	95.4%	of group
110	exceeds lowest	97.9%	of group
116	exceeds lowest	99.3%	of group

Science Meeting Tomorrow's Needs*

By B. Clifford Hendricks,
Teachers' College, University of Nebraska.

In the olden time a watchman stood upon the city wall, and from this vantage point commanded a wider sweep of horizon. Because of this position he was often called upon to answer the question, "What of the morrow?" The high school boys and girls are somewhat like the watchman. They are looking to the coming day; their interest is in the morrow.

Tomorrow will be "different." Four hundred years of change is thus described in terms of its effect upon Columbus, who is assumed as returned to America:

> The telephone amazed him, and he laughed a hearty laugh
> At the music emanating from a wheezy phonograph;
> The wireless seemed like witchcraft to our friend of long ago,
> But the thing he thought entrancing was the marvelous radio;
> And when the evening shadows fell and all the sky was dim,
> Electric lights flashed everywhere and quite bewildered him.

The morrow will bring wonders that were not listed for Columbus. There will be harder things for you to adjust to than Uncle Ezra's lamp, which he found in the hotel. He said he had to sleep with it burning all night, "For the blamed thing was in a bottle and I couldn't blow it out." Moses found a burning bush in the desert, but he couldn't understand why the shrub was not consumed. A freshman class in chemistry at the University of Nebraska a few days ago, saw a piece of paper burst into flame, quite as hard to explain as the bush, and after the flames had died down the paper was no more consumed than was the bush. These moderns were not satisfied, however, until they learned that the paper was covered by a substance that burns at a low temperature, that the same "miracle" could be repeated as many times as they wished, that the same description that accounts for any burning accounted for it. The men and women of tomorrow must take a similar attitude toward the wonders that will come to them: that these marvels, after all, are only special cases of Mother Nature's constancy of conduct; that in general,

* Radio talk to high school students through the University of Nebraska broadcasting station, November 13, 1925.

nature's performances are orderly and dependable, if but understood.

The morrow is going to make a greater demand upon its men and women to *get on pleasantly* with their fellows. Not only is the world getting more densely populated, but the 'phone, the radio, the rapid means of transportation, all aid in reducing distances and making us more and more at the mercy of each other. If all this is not to work discomfort, we as individuals must make more and more of an effort to understand each other, to get the other fellow's point of view. To be specific, students in high schools and colleges will study chemistry and other sciences to know what those fifty or more thousands of scientists who are members of the various science organizations of this country, *are about* and what the results of their work are, just as diligently as they will study Latin and history to be able to understand people who lived twenty, more or less, centuries ago.

New, multiplied wonders and more persons within your acquaintance are bound to bring up more difficulties,—more problems. And of a kind unknown to your fathers and mothers. Some of these, cited from the field of chemistry, will serve to illustrate.

Our modern "wonders" of transportation, the aeroplane, the dirigible, and the automobile, all consume liquid fuels. This fact even now warns us there is likely to come a shortage, unless the chemist can come to nature's aid and produce a substitute for gasoline.

As the population grows, the food supply becomes more and more of a problem. The chemist sees it from three angles: a need for increased natural production, which means a larger appeal to fertilizers, and artificial fertilizers; more attention and care in preventing waste, with means developed for use of all waste, as foods are now handled; improved and more successful methods of producing synthetic foods in the laboratory, much as synthetic silk and similar fabrics are now produced.

Increased population also brings a greater danger from infectious diseases. That means a demand for medicines whose action is fast and certain. This is a field in which chemists are now working very industriously, and it is no mere fiction to say that doctors of medicine may be more surprised at changes made in their field of work in the next fifty years

than Columbus would be in the world at large in the last four hundred years.

All of this serves to point to a great need in our training for life in this tomorrow,—a need for a safe, dependable method of attacking and solving, not only these problems of food, medicine and power, but thousands of others involving social, economic and similar relations. In answer to this, science in general, and chemistry in particular, can do for men and women of tomorrow an invaluable service. Do you suppose radium was found by accident? Was it purely chance that helium was first found in the sun and later with decomposing radium? Hardly. The engineer who is in charge of the construction of Nebraska's new state capitol first laid railway tracks to the site to haul out the dirt excavated and haul in building materials. In other words, he anticipated and planned for needs before they arose. Just as this engineer began his work by doing this advance planning and temporary construction, so the scientist, after he gathers his facts, develops temporary solutions to problems he is working upon. These temporary results are used, as is the railway, in building the permanent, lasting structure, his answer to the difficulty or need. So the scientist always proceeds in a well-ordered manner as he seeks to unravel the perplexities that confront him. This manner of attack upon problems or difficulties has been so successful that others than scientists are each year turning more and more to its plan of work as an aid to them in solving their difficulties. History, sociology and education are among the subjects which are openly using what is called the *scientific method*. This is undoubtedly a method that should be well understood by the citizen of tomorrow.

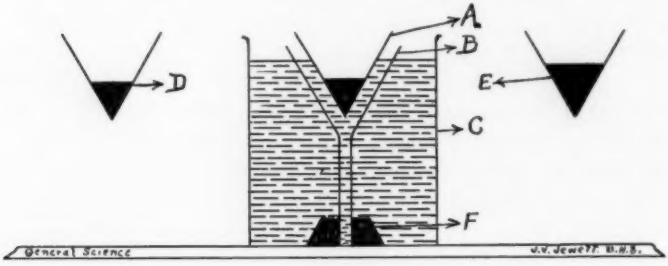
Then, in closing, what shall be said of *your morrow?* New wonders are almost sure to be at your command; but you will command them only if you insist upon understanding them. You will have more neighbors than we of today possess, but to make the most of this privilege it will be necessary that you broaden your sympathies, increase your tolerance for, and deepen your understanding of these neighbors. You will also have your troubles, but these in turn may be dissolved if you learn how to solve them by the safe and sure methods of science.

A Lesson in Osmosis

By John V. Jewett,

Submaster Brookline High School.

There is always difficulty in presenting to a class the subject of osmosis. The usual method of demonstrating with a piece of membrane or parchment stretched across a thistle tube is frequently interfered with and unsuccessful because of breakage and leaks. Nothing is more disconcerting than to have some member of the class discover that the desired results are inverted and the two liquids meet, not through the membrane, but because of imperfection of apparatus. The method presented here avoids any possibility of error, and the apparatus, present in the poorest equipped schoolroom, can be quickly and easily set up.



Osmosis Demonstration.

Use a 1000 c.c. beaker (C), a medium-sized glass funnel (B) held upright by inserting into (F), a rubber stopper. A piece of parchment (A), used in the same manner as a filter paper, will hold the thicker solution and is transparent enough to permit the class to see the solution before, during and after the demonstration. Warm water should be used in the beaker and a thick, warm solution of Karo syrup, colored with red or black ink, in the parchment. D represents the syrup (3 teaspoonsful) and E represents the syrup plus water (4 teaspoonsful) after the parchment has been in the water from 10 to 15 minutes.

In this arrangement there is no possible suggestion of anything but the passage of warm water through the parchment, because every part of the apparatus is before the eyes. After the syrup has been placed in the parchment the class can see that there is no chance for leakage. When the parchment is fastened around the thistle tube there is a constant suspicion that the water can get by the fastening, and this often does happen at the wrong moment.

Statisticians Measure Crops from Train With Crop-Meter

A device for measuring the acreage of various agricultural crops for comparative reports and charts has been successfully adapted to a railway train by statisticians of the United States Department of Agriculture. The instrument is in the nature of an automobile speedometer, and when attached to the gear of the railway car, measures and records the number of feet of each kind of crop along the right of way. It was designed in 1923 for use on an automobile and was first successfully used in that capacity.

The instrument, besides having a regular mileage meter, such as that on an ordinary speedometer, has twelve special dials—one for each kind of crop—with a set of push-buttons which throws them into gear when needed. For instance, when, during the train journey, a field of cotton is being passed, the button indicating cotton is pressed and the number of feet of cotton along the road in that particular field is measured and recorded. If the next field is corn, the operator presses the corn button, and the number of feet in that crop are measured and recorded. If the next field should happen to be idle land, the idle-land button is pushed.

The first railway crop-meter measurements were made recently by a Department statistician, who made a 279-mile trip on a Georgia railway line. The data thus collected can be used to compare the percentage of one crop with another any year, and also the percentage of one crop one year with the same crop in other years by repeating the trip over the same route.—*Washington, Government Printing Office,* 1925.

The Scientific Method and Health

By Paul I. Pierson.
Science Department, Chicago Normal College

I stopped on a corner on the south side of Chicago, near Sixty-third Street, a short time ago, attracted by a medicine vendor. He displayed a chart of the human body, at the same time haranguing the crowd. He had a remedy for uric acid, which was guaranteed to remove this poison from the body. He said that uric acid in the body produced most of the diseases that afflicted mankind. In order to prove the worth of his remedy, he held up a tube of a dark, cloudy solution, which he said was uric acid. Into this he poured some of his remedy. Immediately the solution became clear. Thus, he said, would this powder remove uric acid from the system. Although the people of this part of Chicago are perhaps above the average in intelligence and prosperity, the vendor did a thriving business in the sale of his remedy at fifty cents a package. Apparently the "proof" went home.

It did not seem to occur to these people that they were taking the word of the stranger for at least three propositions: first, that diseases are caused by uric acid; second, that the cloudy substance was uric acid; and third, that the substance that cleared it up was the substance he sold. But the point is not so much these logical errors, as the fact that he went to the trouble to stage this "proof." It was a tribute to the growing scientific attitude on the part of people.

We are emerging from plain superstition. Our advertising abounds with such expressions as "discovered by an eminent scientist," "triumph of science," "endorsed by leading physicians." But this incident also shows that mankind is still very easily misled. Education already has a heavy task, but it would seem that it is the only way by which we can learn to distinguish the true from the false in those matters that affect our health.

There is a method of learning truth called the scientific method. By it we have discovered that the phenomena of our physical universe occur according to laws. As we discover these laws we are able to control our environment to an extent

never before possible. From our knowledge of these laws we have developed our radio, telephones, railroads, automobiles, aeroplanes, and the thousand and one things that make this the greatest mechanical civilization ever known. But it seems that the mass of mankind is slow to appreciate that the biological laws are just as definite, and in some cases as well known as physical and chemical laws. At any rate, people seem to be very easily misled by pseudo-science in the realm of health and the cure of disease.

We teachers must first be thoroughly convinced that the scientific method is the means by which the truth should be learned about health, that it is the only method that produces results. And we need further to learn how this method is used so that we can distinguish that which is scientifically sound from that which is not. This task is not easy.

We can, for convenience, divide this method into separate steps, although these are not necessarily separate and distinct in actual practice. First, is the collection and observation of facts; second, the classification of these facts observing likenesses and differences and causal relationships; third, formulating hypotheses to account for the facts; fourth, testing these hypotheses by further facts; and fifth, deducing the laws which govern our facts. A very large part of our laboratory and research work comes under the fourth step. Let us illustrate this by a brief story of the discovery of the cause of yellow fever, for this is a brilliant chapter in the history of disease control.

Certain facts concerning this and other similar diseases led to the mosquito theory of its cause. But further proof was needed. A commission on yellow fever in Cuba, composed of four doctors, undertook the proof. These men were Reed, Carroll, Lazear, and Agrimonte. Protecting themselves from mosquitoes, they tried other probable means of infection. They slept with yellow fever patients, wore their clothes, and ate from dishes used by them. But they did not contract the disease. Then Carroll and Lazear allowed themselves to be bitten by the suspected mosquitoes. The result was that Lazear died of yellow fever and Carroll was near the same end. To make the proof more certain, soldiers of the American army in Cuba volunteered to undergo the same risks. And then came the benefit of knowing nature's laws. Armed with certain knowledge, the Sanitary Commission, under Dr. William

C. Gorgas, exterminated the stegomyia mosquito in the Canal Zone, and with it yellow fever, thus making it possible to build the Panama Canal. But it is interesting to note that it took an epidemic in 1905 to convince the people in the Canal Zone that the scientists were right. After this, however, Dr. Gorgas and his Commission were given full reign in sanitary matters.

The scientific method is based on determinism. This merely means that we assume that nature acts according to law, and not capriciously. We expect that certain conditions produce certain results and if we duplicate these conditions we will get the same results. This method is further based on logical thinking as opposed to emotional thinking, and here is where many of us get into difficulties. We are biased by what we would like to be true, by views we have held for a long time, or by what we get from those who seem to us "authorities." It is hard to be open-minded and unprejudiced. We are prone to draw conclusions and base our judgment on insufficient evidence. The average man has little idea of the rigorous proof and abundant evidence that must be obtained before scientists will draw general conclusions. And even then the scientists must be open-minded in the face of new evidence.

We are very apt to mistake cause for effect, and vice versa. When two things happen simultaneously, or successively, we are not justified in the conclusion that one causes the other. Many of our physiology texts have taught that cigarette smoking causes low mentality because these phenomena often occur simultaneously. It is at least possible that the smoking is caused by low mentality or that both come from a remoter cause. These are some of the errors of logic into which we fall. But even after we recognize these errors and guard against them, we are often at a loss to know what to believe in health matters. Authorities themselves disagree and the layman is puzzled.

Here are a few suggestions. Beware of the "secret" discovery, or the exclusive method. One may patent an invention and derive financial benefit, but not with honor may a discovery of benefit to the health of mankind be kept secret. One must give such a discovery to the medical world. Thus did Dr. Banting with his insulin treatment for diabetes, and so must all reputable doctors and scientists.

Use your critical judgment on the "authority" who would gain financially if you took his advice or accept his ideas. Just as you should guard against emotional bias in your own thinking, so be on guard for bias on the part of the other fellow who has a financial axe to grind.

Let us understand that very many things about health and disease are not settled and we have to educate this judgment of ours to take the side of the "more probable." There are degrees of scientific soundness, varying from the certainly proved to the very doubtful. For instance, it is known that certain diseases, like typhoid fever, are caused by bacteria; for others there is strong presumptive evidence of the same cause, but definite proof is lacking. For still others the cause is doubtful or unknown.

A word about authorities. The standing of men with others in their profession and the schools in which they were trained are guides. The science of our leading universities and medical schools, both state and private, is as sound as we can find. We have to exercise our judgment, however. There is no substitute for brains.

Finally, here are some questions upon which we can exercise our thinking powers. To some the answers are definitely known. Others are still matters of dispute. Every teacher interested in health training should be able to give an opinion or definite answer to them. You may have to search for facts or data or opinions of others, but beware of emotional bias. If you feel strongly or get a little "warmed up" in considering or discussing them, mistrust your conclusion.

1. Do drafts cause common colds.
2. Do you ever suffer from lack of oxygen?
3. Is night air injurious?
4. Do drugs usually cure disease?
5. Under ordinary circumstances are you ever poisoned with carbon dioxide?
6. Is a healthy person, unvaccinated, likely to take smallpox after exposure to the disease?
7. Does the perspiration contain poisonous waste matter?
8. Will salts in bath water remove fat?
9. Is the science of the *Physical Culture Magazine* sound?
10. How about that of *Hygeia*?

11. Which magazine would be the better authority on mental health, *The New Psychology*, or the *American Journal of Psychology*?

12. What is the cause of cancer?

13. Is there any cure for it?

14. Is the foundation of the Chiropractic method of curing disease sound?

15. Can you protect yourself from possible typhoid fever? If so, how?

16. Can children be protected from possible diphtheria? If so, how?

17. Will your good intentions save you from the consequences if you are ignorant of nature's laws?

—Reprinted from *Chicago Schools Journal.*

Getting Minerals from Sweets

Many persons eat things they do not like for the sake of getting needed minerals in the diet. It is well, therefore, to know how to supply minerals in attractive form, says the United States Department of Agriculture. Cookbooks have for many years carried recipes for a kind of confection known as Parisian sweets, made by finely chopping and mixing equal weights of dates, figs, and shelled walnuts. This mixture is usually formed into caramel-shaped pieces or into balls which are rolled in sugar to reduce their stickiness. Or it can be spread between slices of bread, and if it happens to be graham bread the product is a sweet sandwich in which mineral is added to mineral. If we compare a sandwich made of 1 ounce (two small slices of graham bread) and 1 ounce of the mixture mentioned above—or, in fact, almost any combination of nuts and dried fruits—with a sandwich made from the same amount of white bread spread with butter and sugar, we find that the former has more than six times the calcium, more than twice the phosphorus, and, best of all, since iron is hardest to find among foods in common use, more than four times the iron. This one sweet sandwich, in fact, supplies one-tenth of all the iron needed by a grown person in the course of a day.

The Value of Astronomy in a General Science Course*

By H. A. Richardson, Head of Science Department,
Ottawa Hills High School, Grand Rapids, Mich.

Of all the sciences from which facts are drawn in the building of a course in General Science, I cannot think of many for which there seems to me to be more justification for including facts from them in such a course, than Astronomy. I wish to state a few of the reasons for the faith that is within me. I am not an astronomer, nor a near one, but I have some deep convictions on the subject, born of several years of teaching General Science and including some work in elementary astronomy in the courses taught.

Along with facts about the numbers of the solar system, the stars and other heavenly bodies, within the term "Astronomy" I include the elementary earth relations, causes of the change of seasons, the cause of day and night, the subject of time, and kindred subjects, some of which are touched upon in the grade geography and some of which were taught in the courses in physiography. It goes without saying, that the pupils entering the eighth or ninth grades understand these topics none too well. It is a rare pupil indeed who does not express surprise if told we have our summer when the earth is farthest from the sun, but who also does not want to know what then is the cause for that season. It also goes without saying, that the pupil has a better opportunity to learn and remember the fundamentals of these things than ever before.

First of all, it is a subject in which almost all pupils of the junior high school age and grade are much interested. I would not say that this alone justifies its presence in the course, but we will all admit that this fact is decidedly in its favor. The representative of a book company a while ago was showing a general science text which seems to possess several points of real merit. But when he was asked why the book did not contain anything in regard to elementary astron-

* Delivered before the General Science Section of the Science and Mathematics Association of Southwestern Michigan, April 24, 1925.

omy and earth relations, he said pupils of the age who use the book are not interested in those things. The teacher at once asked him if he had ever taught a class in General Science, and he replied that he had never taught a day of any subject in his life. Surely, if he had, he would not have made such a statement so far from the truth.

Possiby one reason for this interest in the subject is because the far-away or difficult or the seemingly impossible always holds a challenge for the human mind. I think this is one explanation why the class discussions of molecules and atoms and electrons never fail to awaken enthusiasm.

There are also mysterious appeals of the heavenly bodies to the human mind, some of which appeals are doubtless born of religious or superstitious reverence for things celestial, and some from a greater or less consciousness of the influence of the sun upon all members of the solar system and the importance to us of this great, life-giving heavenly body.

Is it not worth while that pupils should gain a better idea of the importance of this great body to us? The great scientists are more and more being impressed with the possible usefullness of knowledge they now have or may gain in regard to the sun.

Possibly another reason for the interest manifested in Astronomy is because it will afford the pupil an opportunity to ask and have discussed such perennial questions as these: "Is Mars inhabited?" "Are there systems of planets around other stars, similar to our own solar system?" "Are there other planets not yet discovered?" "How can they tell how far away the stars are?" "Why does the moon change its appearance?" "How is the size of the plants determined?"

A little study of Astronomy acts as an eye-opener to the pupil as to the size and extent of the universe of which he is a part as hardly anything else could do. How could it be otherwise, especially in these present days? There is hardly a professional astronomer anywhere today who has not, within the last few years, even within recent months, had his concept of the size and extent of this universe—perhaps I ought to say, these universes—enlarged many fold. As many of you know, one way in which it has been brought about is by the discovery by photographic means, in connection with the great

telescopes, of Cepheids in the distant Magellanic star clouds and the great spiral nebulae, the latest ones discovered being in the great spiral nebula of Andromeda.

What a fine chance for the pupil to learn something of the size of the physical universe, and also of the universe of possible human knowledge. Here was a spiral nebula, its existence known for scores of years, visible to the naked eye, and the nature of which becomes easily discernible with a small glass. Then, the other day came the discovery by Dr. Hubble, in that great "island universe," of the Cepheids, which are variable stars. To Dr. Shapley, of Harvard College Observatory, belongs the credit for having worked out the method for computing distances by these bodies. By knowing their period of variability, their absolute brightness can be determined. Then, by comparing their absolute brightness with their brightness as seen through the telescope, their distances can be computed. Thus new knowledge has been gained as to the distance and size of this great nebula. And the advent of this new knowledge has pushed outward into space our concepts of the size of creation. Thus new facts are constantly being acquired in regard to objects and things both far away and right under our feet.

For another thing, this subject is rich in opportunity for pupils to learn many of the important facts and principles of science, such as gravitation, and facts about light and heat, some of which might not be touched upon in any other place in the general science course.

Along this same line of thought, here is also fine opportunity to vitalize principles of mathematics which otherwise would have but little meaning. First bring out the fact that the diameter of Jupiter is more than 10 times that of the earth, but that its volume is over 1000 times greater, and the normal pupil will want to know how you figure that out. And if you now develop the fact that a person on Jupiter would weigh, not 1,000 times, but about 500 times as much as on the earth, a fair concept of the term "density" will have been gained. Or, illustrate the laws of gravitation, which say that it acts with a force directly proportional to the mass and inversely proportional to the square of the distances, and this mathematical language takes on a new meaning at once.

Then there is the value that comes from the biographies of the men who founded the science of astronomy, or made great contributions to it. At the present time I cannot recall a single science within the firmament of whose history there is a more wonderful galaxy of human stars of the first magnitude than this one. I maintain that the pupil would be a most unpromising one who, upon simply reading something of the life and work of Galileo, Newton, La Place, Halley, Kepler, Copernicus, Herschel and others, would not receive at least some slight inspiration to be something and do something worth while with his own life.

In this connection I might say that very recently universities and colleges have been trying to make it possible for a greater number of men and women to give their lives over to doing research work, to become searchers after truth. We know all pupils are not adapted for such work, but I do believe the early planting of the seed of desire and purpose for doing such work would yield fruitful harvest in years to come.

Someone has said that truth is a sacred thing, and I think we ought to so consider it. Where better than in Astronomy do you find examples of men laboring for years to discover or confirm one single fact of truth. Not long ago an astronomer completed a task which extended over several years, for finding the parallax of a single star. Dr. Moulton, who a few years ago spoke to this association, worked out problems in celestial mechanics that extended over several years. We ought also to remember that every truth seems to have some relationship, be it ever so apparently remote, to every other truth in the universe.

Furthermore, one never knows what new application will be made of a new truth just discovered or an old one known for centuries. When Lockyer, in 1868, at the time of a total eclipse of the sun, was examining the corona with the spectroscope and discovered helium, little did he think he was finding a safe substitute for hydrogen for lifting our dirigible balloons and airships. The geologist now tells us he is estimating the age of the earth by using the time for the disintegration of radium as his scale. Next we learn that the great oil companies are employing this knowledge for more efficiently prospecting for petroleum. And of course it is by means of truth

obtained from the "friendly stars" that we navigate our ships and bring to our doors articles of food, clothing and shelter from the four corners of the earth, and that we measure time,—"the stuff of which life is made." It is in such ways as these that we can answer the questions of pupils and adults as to what good it does or of what practical benefit it is to study about those heavenly bodies, so far away.

From this wonderful array of famous workers in Astronomy, one of those from whose life many valuable lessons can be learned is William Herschel, the musician-astronomer. I like to call attention of pupils to the fact that here was a musician who studied mathematics and astronomy and made telescopes, for his avocation,—who got fun out of doing hard things. It seems to me this is something of which many of our youngsters know too little.

Here is also a lesson, I think for us grown-ups, as well as our pupils, and that is what we can accomplish with our own unaided efforts if we really try. Many people have the notion that the study of astronomy is a forbiddingly deep and difficult subject. There are phases of it that are difficult indeed. But almost all the facts of elementary or descriptive astronomy, and many of the more difficult phases, can be learned by almost anyone by his own efforts, with a little careful thought and study.

The lesson of careful, accurate observation is another one we have a chance to teach. They tell us it was the power of keen observation, coupled with years of tireless effort, that won for Herschel the prize of the discovery of Uranus. Many an astronomer had seen that same object before the critical eye of Herschel fell upon it. It is the exception to find a pupil who knows for sure, from his own observation, whether the stars rise and set each day, whether the moon rises each day, whether the stars are in the same direction the year around. All these, and many more, are things which the normal young pupil could discover for himself, and enjoy the thrill that comes from self-discovery. Try it yourself some night, by taking a copy of that admiral little journal, *The Evening Sky Map*, published by Leon Barrett of Brooklyn, N. Y., and a good spy-glass, and go out and find Uranus.

Naturally enough, many of you do not assign as high a value to many of these possibilities as I may happen to do. We all must admit that some of them are concomitants,—things or phases that are attendant with some of the more conscious or definitely purposed phases of the subject. But the modern-day educators tell us that pupils learn almost as many valuable lessons, especially those that make for character, in the concomitants as in any other part of the work of the school.

Teaching Science vs. Teaching Facts

By LOWELL C. FROST,
Hollywood High School, Hollywood, California.

It is better to be good than it is to be bad. There are probably few who will dispute the validity of this proposition. *Science as a method of thinking is more valuable than science as a collection of facts.* "Equally true, and equally trite," would be the righteous and almost unanimous verdict of science teachers on this second statement. Yet, in spite of our theoretical belief in the betterness of goodness, some of us still exhibit remarkable lapses which would seem to throw doubt on the efficacy of our belief. And among teachers of science you may easily find those who distribute facts for their pupils to hoard up, as old gentlemen in the park distribute nuts to squirrels. It has been found, by the way, that the squirrels gather many more nuts than they can ever need, and that they very quickly forget where they stored a goodly portion of them. The writer would be loathe to deny the value of facts—or nuts; but he deprecates the mere collection of facts or nuts for their own sakes.

The teaching of factual information is the easy road to a salary for the weak teacher. It is dangerously simple to assign four pages in the text, and to check off the ability of each pupil to remember the items of information contained therein. But the method is really self-defeating, for too great stress upon the remembering of facts is almost certain to leave them unrelated to each other and to thought processes. And it is common experience that an unrelated fact is a fact lost to memory.

A consideration of the unrelated fact leads to a further indictment against it. Any fact faces the past. A fact is, from a study of the word itself, a *fait accompli*—a "thing done." Only when they have joined hands at the behest of an idea, can facts face the future with significance. Single facts are static; joined by a logical thought they are dynamic. Facts are essentially raw materials, and it requires the catalytic action of thought before they can be combined into a useful product. That photosynthesis is the process of manufacturing carbohydrates in a green leaf, is an interesting fact; but it is unproductive until logically linked with the further facts that carbohydrates are the sole fundamental sources of protein, and that protein is essential to the life of every living thing.

Moreover, is it worth while to burden many minds with many facts, while we have so many good reference books at hand? I know a teacher of geometry who can never remember the value of *pi* beyond the fourth decimal, and who keeps the required figures, along with other facts, in a pocket note book. He seems, however, to make geometry a joyous and vital thing to his pupils. His mind is full of living thoughts, his notebook of formulae.

It would seem, then, that the true function of a teacher of science is to inculcate in the pupil the habit of using thought effectively in dealing with facts. The pupil may get the facts from a few good books, but he will not get the habit of straight thinking about them from few or many books. He must have a real teacher if he is to comprehend real science.

The most valuable contribution to scientific education during the past score of years has been the wide adoption of General Science as a ninth year subject. There is, however, no great advance without some danger, and in this case the danger has manifested itself in a tendency toward making the course in General Science a combination of miniature courses in each of the sciences. This tendency results from a total misconception of the purpose of such a course, which should be, I believe, to use the fundamental conceptions of many of the departments of science in building up a scientific attitude of mind on the part of the pupil. This purpose should never be subordinated to that of providing the pupil with a substitute

in the form of necessarily inadequate samples of Physics, Biology, Astronomy, and the other sciences. Even in the later years of high school sciences, the primary aim should be *Science* as a whole, and every high school teacher in the Science Department should be *first*, a teacher of *Science;* second, a teacher of Chemistry, Physics, or other particular branches of science. For if the scientific attitude is not acquired in high school, it is rarely attained later, and every university teacher will support the statement that it is the ability to think straight rather than the storage of any amount of information, which determines the capacity of the student for carrying on advanced work effectively.

Thus far we have been discussing the end to be sought, and the writer hopes and believes that most of his colleagues will be in substantial agreement with his thesis. As to the methods to be pursued, he expects a wide scattering of opinions—which is, of course, as it should be. The strongest teacher is he who most clearly and constantly visualizes the end to be attained, and who most successfully evolves and adapts his methods in accordance with his individual powers and the needs of his particular pupils. Ends should be agreed upon; means should be individual.

There are, however, certain general assumptions in the teaching of science which, although widely accepted, are too seldom clearly expressed. Three of the more important of these might well be listed in categorical form.

1. *Scrupulous maintenance of a scientific attitude on the part of the teacher, and avoidance of "scientific" dogmatism.* Any teacher who is afraid to say "I do not know," is more dangerous than useful in a science deparment.
2. *Every statement, question, and answer, of both teacher and pupil, should be accurately expressed and completely expressed.* Any loose wording of statement, question or answer, should be attacked and criticised by the class, and so amended as *exactly* to express the thought intended.
3. *Every opportunity to ask "Why?" should be utilized.* In modern educational parlance, the "neuristic" method should be employed.

Every reader of this article will wish to add to this short list, and the writer desires to exercise the same privilege. He would include in it

The adequate presentation of the fundamentals of logic in every science class.

This should embrace the study (not the mere memorization of definitions in the first chapter of some textbooks) of axioms, assumptions, hypotheses, theories, laws, syllogisms, fallacies, and the validity of generalizations. How many students in any senior science class know and can state what they actually mean by the phrases "I guess," "I suppose," "I believe," "I think," "I know"? How many know what factors justify a generalization, or are able to detect common yet plausibly-worded fallacies? Yet a working knowledge of these things lies in the very foundation of scientific thinking. The obvious outcry against such an innovation is that logic cannot be understood by most adults, and that it is therefore absurd to teach it in high schools. To which one is tempted to retort that if the adults had been taught something of logical scientific thinking when they were in school, they would now be able to understand more of logic, and many other things. The real answer is that it is actually much easier to teach practical logic to a high school pupil than to an adult. It is easier to walk straight across an untrodden field than it is to do the same across a field worn with many crooked paths. A study of the fundamentals of logic does not necessarily imply stilted phraseology, abstract theorizations, nor the medieval clap-trap of the word-juggler. It may be taught (best, perhaps) with the aid of material taken from the Sunday paper, as a basis for critical discussion.

That the child's mind is inherently more logical than the mind of the adult is a fact observable and provable by anyone. That we allow it to remain a fact is the most terrifying indictment of our educational system.

Massachusetts Department of Public Health

FOOD RULES FOR SCHOOL CHILDREN

1. Begin the day by drinking a glass of water and drink at least six glasses during the day.
2. Do not go to school without breakfast.
3. Eat regularly three times a day.
4. Eat slowly and chew all food well.
5. Drink milk every day—four glasses are not too much.
6. Eat some breakfast cereal every day.
7. Eat some vegetable besides potato every day.
8. Eat bread and butter every meal; dark breads are best.
9. Eat some fruit every day. Spend the pennies for apples instead of candy.
10. Do not eat candy between meals; eat candy and other sweets only at the end of a regular meal.
11. Do not drink tea or coffee; it does the body no good but does do it harm.
12. Do not eat or touch any food without first washing the hands.
13. Do not eat fruit without first washing it.
14. Do not eat with a spoon or fork which has been used by any other person without first washing it.
15. Do not drink from a glass or cup which has been used by another person without washing it.
16. Do not eat from the same dish with any other person.

A. W. SANDWALL

AMERICAN PUBLIC HEALTH ASSOCIATION

370 Seventh Avenue, New York City

WHEREAS, hundreds of thousands of dollars are wasted every year on this continent in the installation and operation of systems of school ventilation which are not only not beneficial but are positively harmful to the health of the school children, and

WHEREAS, in the light of current knowledge, the supply of as large an air volume in school rooms as 30 cubic feet per minute, per capita, is necessarily accompanied with dangerous overheating of the schoolroom in order to avoid resulting drafts, and

WHEREAS, the use of ozone and other chemicals for treating schoolroom air has little or no scientific justification and little or no practical value;

RESOLVED: That the system of ventilating schoolrooms by fresh, untreated, outdoor air, admitted at the windows, with gravity exhaust ducts for removing vitiated air from near the ceiling, is the most generally satisfactory method of school ventilation; and

RESOLVED: We recommend that state laws and city regulations interfering with such scientific and economical methods of school ventilation should be repealed in the interest of the public health.

October, 1925.

Evidently there is still room for more project work on ventilation. It is still a very much open question, particularly as to the importance of humidity.

More Science in Elementary Schools Urged; Superintendent Jones Says City Children Have Special Need for Nature Study

By Supt. R. G. Jones.
Cleveland, Ohio.

From his Annual Report for 1924-25.

In Cleveland, as in other large centers of population, children need to know something of natural forces and phenomena. School gardens but partially fill this need. The story of the planet on which we live, our world's relationship to other planets and heavenly bodies, the fascinating narratives of the seas and continents, mountains and plains, rivers and lakes, the great epic of the development of life—all of these should be part of every child's education.

In our own city, as elsewhere, this phase of education has been neglected, especially in the elementary schools. Yet it is the background required for an understanding of science.

Applied science is the dominating characteristic of the age in which we live. To be without an understanding of science and its possibilities when applied, is to lack an essential part of education.

Knowledge of geology, astronomy, botany, and zoology are truly cultural. The number of persons, moreover, whose work involves the applications of science is very large and constantly growing larger.

Artificiality Increasing.

Part of the price we pay for the advantages of living in a large city is an increasing artificiality which tends to prevent the wholesome development of character and of mind. Elemental requirements, such as transportation, heating, lighting, sanitation, and food supply, are provided for us almost automatically. Under ideal conditions every child would enjoy a liberal amount of out-of-door life; every boy and girl through first-hand experience would learn the elemental needs of physical life and how to supply them—food, pure water, heat, light, sanitation, and the rest.

We cannot expect such conditions to be realized, but we can and should emphasize in our schools and in the elementary grades a study of the natural sciences which involve all of these. The Museum of Natural History is full of promise in this connection.

In the same connection are functioning such organizations as the Boy Scouts, the Girl Scouts, and the Camp Fire Girls. All of these have a considerable membership in Cleveland. They are of very real help in promoting the education of boys and girls, in emphasizing and supplementing the work of the public schools.

"What's in a Name?"

We have all followed with interest the gradual adoption of the word "Methanol." The term "Methanol" came into scientific or chemical usage as a result of the action of the International Conference of Chemical Nomenclature which met in Geneva, Switzerland, in April, 1892. One of the resolutions adopted at this conference was as follows: "The alcohols and phenols will be called after the name of the hydrocarbons from which they are derived, terminating with the suffix *ol;* as for example, methanol, ethanol, etc." The report was published in 1893 but did not meet with much favor in the American scientific circles until 1920. In that year the American Chemical Society sponsored this name. It now occurs in many trade price lists, and such magazines as the Literary Digest occasionally make use of this term.

Now the word "rayon" is being placed before the public. About two-thirds of the "silk" now in use is a product of the chemist rather than the silk worm. This product made from cellulose has as yet no common name. It has been called by such name as "artificial silk" and "imitation silk." This is not good practice as these products are not the same as silk and do not pretend to be. Last year most of the manufacturers of this synthetic silk agreed to adopt and introduce through advertising the name "rayon" for all products of this sort. Some of the makers refuse to accept this term and still use their own trade name.

Why Clocks Keep Time

By O. E. Underhill, Normal School, Salem, Mass.

This is the sixth of a series of question and answer lessons.

(It is assumed that the pupils have been assigned readings on Galileo. See "Through the Ages of Time," in the November number of the General Science Quarterly.)

Teacher. I am sure that you have learned a great deal about Galileo since our last lesson. What can you tell me about him?

Mary. He invented the thermometer.

John. —and the telescope.

Alice. He dropped some weights from a high tower to see how fast they fell.

Beatrice. He watched some lamps swinging in a church.

Teacher. Yes, he did all of those things. And why, Beatrice, was he interested in watching some lamps swinging in a church?

Beatrice. He noticed that no matter how far a lamp swung, the time of each swing was the same.

Teacher. How did he know the time of each swing was the same? Watches and clocks were not invented then.

Beatrice. He timed them by his pulse.

Teacher. I wonder if we couldn't try that experiment here. I have a piece of string. I will tie this book at the end and it will serve as a pendulum in place of Galileo's lamp. I will hang it up in the doorway, so that it may have a place to swing in. Can you find your pulse? Feel for it right here in your wrist. Put your fingertips on the palm side and your thumb on the other side. That's it. Charles, you hold the book up in the air ready to let it swing. Mary, you say "Go," and start counting your pulse. When you have counted twenty, say "Stop." John, while the book is swinging you count the number of swings it makes before it stops.[1]

Mary. Go.....Stop.

John. It went sixteen times.

---

[1] A piece of string about two feet long will give approximately the figures which follow. To be most effective the period should be such that it swings somewhat faster or slower than the pulsebeat, rather than to coincide with it very closely.

Teacher. Now do the same thing again, only this time, Charles, lift the book about half as far as you did before.

Mary. Go.....Stop.

Charles. It went sixteen times that time, too.[2]

Teacher. Yes. You have found out just the same thing that Galileo did. Can you suggest anything that we might do to this pendulum to make it swing at a faster or slower rate?

Alice. Make it heavier.

Teacher. All right; let's try it. I will tie three books onto the string instead of the one.[3] Now try it.

Mary. Go.....Stop.

Charles. Why, it went sixteen times that time, too.

Teacher. What does that show, then?

Charles. That it doesn't make any difference how heavy it is.

Teacher. Now you have learned two things about a pendulum. What are they?

Dora. A pendulum takes the same length of time to swing, no matter how heavy it is, or how hard you swing it.

Teacher. Yes. Can you suggest something else we might do to change the rate of swing?

Charles. Would changing the length of the string make any difference?

Teacher. Try it, and see.

(Charles shortens the string and the experiment is tried as before.)

Charles. It went twenty-five times that time.

Teacher. Now you have learned three things about a pendulum. Can you tell us what they are, Frank?

Frank. If the length of a pendulum is made shorter, it swings faster, but changing the weight or swinging it harder doesn't make any difference in how fast it swings.

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[2] It might be well to take an average of several tries in each case, as slight pulse variations, and uneven starting and stopping in counting, may make a change of one or two in the number of swings. Then, too, the idea of checking data by numerous observations is not a bad one to work in whenever opportunity offers.

[3] Care must be taken here in making the change, that the distance from the point of suspension of the string to the center of gravity of the book or books is not changed.

Teacher. That is right. Now what did Galileo do after he found out that no matter through what distance the lamp was moving it took the same time to swing?

Charles. He invented a machine for doctors to measure how fast a person's pulse was beating.

Teacher. Isn't that interesting? After timing the swinging lamp by *his* pulse, Galileo then used this idea of a swinging pendulum to measure the pulse-beats of others.[4] How was this fact that Galileo learned while watching the lamp swing, made use of to enable us to tell the time?

Elsie. In pendulum clocks.

Teacher. What does the pendulum in a clock do? . . . No one knows. I will show you a clock and then see if you can tell. This clock is run by a weight. You do not see many of them now. Most of our modern clocks are run by springs.

(Children observe the model clock. A very good demonstration clock, which comes entirely taken apart and may be easily assembled in a few minutes, may be purchased for a few dollars. A clever student should be able to rig up a train of gears from an old alarm clock and solder a pendulum to the escapement lever, so that it will serve to illustrate this lesson.)

Teacher. I will take the pendulum and the escapement lever out of the clock. Now watch what happens.

(The weight falls rapidly and the hands whirl around.)

Beatrice. My! doesn't it go fast?

Teacher. Now, I will put the pendulum and escapement lever back.

Charles. The bent-over ends of that lever catch in the teeth of that wheel, so that it cannot go fast.

Teacher. The wheel you speak of is the escapement wheel. Notice that the teeth are slanted so that they push against the turned-down ends of the escapement lever. The weight, or if it is a modern clock the spring, turns the gear wheels which turn the escapement wheel. The slanting teeth in turning push the escapement lever back and forth, but it can only go as fast as the pendulum in swinging will let it. When the

[4] Various pupils may shorten or lengthen the string until the pendulum swings in time with their pulses, thus comparing their rates of beating.

wheel pushes one side of the escapement so that the pendulum swings one way, the other side of the escapement drops into the teeth of the wheel, so that it cannot go any further until the pendulum has swung back again. So it goes—back and forth—back and forth—no faster than the pendulum can swing. Now how can we make our clocks go faster or slower?

Charles. By changing the length of the pendulum.

Teacher. That is right. Now you see how the pendulum regulates the clock. The weight or spring tries to turn the hands around, but the escapement, regulated by the pendulum, will only let them turn a little at a time.

Mary. How are alarm clocks and watches kept from running too fast? They have no pendulum.

Teacher. You know what the hairspring in a watch is, do you not?

Mary. Yes. It is that little spring which keeps twisting and untwisting.

Teacher. That hairspring is the thing that controls the escapement in watches and in clocks that have no pendulum. The first thing that was so used was the stiff bristle of a pig. As the hairspring coils and uncoils it allows the escapement to move back and forth much as the swinging pendulum does in this clock. Now, how do we know when our clocks are right?

John. We get the time over the radio.

Teacher. How does the station which is broadcasting know what the correct time is? See if you cannot find out how we determine what the correct time is, and be ready to talk about it next week.

READING REFERENCES THAT MAY BE ASSIGNED.

How do we get correct time?—Everyday Problems in Science—Pieper and Beauchamp.
Time (various references)—Everyday Science—Snyder.
Various Elementary Astronomy texts.
Various Physical Geography texts.
Astronomy for Busy People—Hawkins.
Astronomy for Young Folks—Lewis.
Descriptive Astronomy—Moulton.

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Vol. I, No. 3, p. 170
Vol. II, No. 3, p. 394
Vol. III, No. 1, pp. 2, 6, 39
Vol. IV, No. 1, p. 297
Vol. IV, No. 2, p. 347
Vol. V, No. 2, p. 88
Vol. VI, No. 2, p. 415
Vol. IX, No. 4, p. 232

Astronomy

Vol. III, No. 1, pp. 11, 35

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Vol. II, No. 3, p. 396

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Vol. VII, No. 1, p. 24

Vol. I, No. 1, p. 55
Vol. III, No. 1, p. 25

Cement and Concrete

Vol. VIII, No. 4, p. 572

Clothing

Vol. II, No. 4, p. 293
Vol. IX, No. 4, p. 235

Colors

Vol. II, No. 3, p. 410

Communication

Vol. VIII, No. 2, p. 425
Vol. IX, No. 4, p. 247

Electricity

Vol. III, No. 1, p. 13
Vol. III, No. 4, p. 231
Vol. IX, No. 3, p. 173
Vol. III, No. 2, p. 111
Vol. VI, No. 1, p. 335
Vol. IX, No. 4, p. 245

Energy and Work

Vol. III, No. 1, pp. 13, 31
Vol. IX, No. 2, p. 122

Explosives

Vol. II, No. 2, pp. 345, 353
Vol. IX, No. 1, p. 58

Fire Prevention

Vol. IV, No. 3, p. 409
Vol. V, No. 3, p. 156
Vol. IV, No. 4, p. 456
Vol. V, No. 4, p. 232
Vol. VI, No. 2, p. 409

Eye and Light

Vol. I, No. 1, p. 55
Vol. I, No. 2, p. 111
Vol. II, No. 3, pp. 395, 410
Vol. VI, No. 1, p. 313
Vol. VI, No. 3, p. 489

Food

Vol. I, No. 3, p. 188
Vol. II, No. 2, pp. 337, 402
Vol. III, No. 2, pp. 113, 146
Vol. V, No. 1, p. 36
Vol. V. No. 3, p. 166
Vol. VII, No. 2, pp. 112, 135
Vol. I, No. 3, p. 168

Gas Engines

Vol. I, No. 4, p. 236

Gas—Illumination

Vol. I, No. 4, p. 213

Heat and Fuel

Vol. I, No. 2, pp. 73, 74, 97
Vol. I, No. 4, p. 217
Vol. II, No. 1, p. 353
Vol. II, No. 3, p. 392
Vol. II, No. 4, p. 469
Vol. IV, No. 2, p. 319
Vol. III, No. 2, pp. 89, 118
Vol. III, No. 4, p. 227
Vol. VIII, No. 3, p. 505
Vol. V, No. 1, p. 32
Vol. V, No. 3, p. 141
Vol. IX, No. 1, p. 12

Illumination

Vol. I, No. 4, p. 213
Vol. III, No. 2, p. 91
Vol. III, No. 4, p. 232
Vol. IV, No. 2, p. 319
Vol. V, No. 3, p. 177
Vol. V, No. 4, p. 237
Vol. VI, No. 2, pp. 402 408
Vol. VI, No. 3, p. 478
Vol. VIII, No. 4, p. 596

Lightning

Vol. 1, No. 1, p. 23

Molds, Mildews and Bacteria

Vol. IX, No. 3, p. 156

Nitrates

Vol. II, No. 2, pp. 345, 353

Photosynthesis

Vol. VIII, No. p. 556

Radio

Vol. VI, No. 4, p. 533
Vol. IX, No. 4, p. 259

Soil

Vol. III, No. 1, p. 21
Vol. VI, No. 4, p. 531
Vol. IX, No. 4, p. 238

Storage Battery

Vol. VI, No. 1, p. 322

Submarine

Vol. II, No. 4, p. 234

Transportation

Vol. IV, No. 2, p. 345

Water

Vol. I, No. 1, p. 15
Vol. I, No. 3, p. 181
Vol. II, No. 3, p. 393
Vol. III, No. 1, pp. 3, 10.
Vol. III, No. 2, p. 107
Vol. VII. No. 1, p. 59
Vol. VI, No. 3, pp. 461, 495
Vol. VI, No. 4, p. 551
Vol. VII, No. 4, p. 274
Vol. VIII, No. 2, p. 422
Vol. VII, No. 2, pp. 133, 126, 127
Vol. IX, No. 4, p. 236

Weather

Vol. I, No. 2, p. 124
Vol. II, No. 3, p. 395
Vol. III, No. 1, p. 5
Vol. VIII, No. 3, p. 500
Vol. IX, No. 1, p. 18
Vol. IX, No. 2, p. 112
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Vol. III—No. 2, p. 65; No. 3, p. 167.
Vol. IV—No. 4, p. 443.
Vol. V—No. 2, pp. 61, 65. 77; No. 3, p. 123; No. 4, pp. 199, 219, 226.
Vol. VI—No. 2, p. 386; No. 3, pp. 433, 448; No. 4, p. 511.
Vol. VII—No. 2, p. 102; No. 3, pp. 157, 167, 181, 188.
Vol. VIII—No. 3, pp. 463, 481, 497; No. 4, pp. 541, 564.
Vol. IX—No. 1, pp. 1, 9, 38; No. 2, pp. 79, 84, 91; No. 4, p. 231.

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Vol. I—No. 1, p. 13; No. 2, p. 67; No. 3, p. 166.
Vol. II—No. 3, p. 379; No. 4, p. 419.
Vol. III—No. 1, pp. 31, 33, 40; No. 4, pp. 195, 209.
Vol. IV—No. 1, pp. 268, 283; No. 2, p. 343. Vol. V—No. 4, p. 254.
Vol. VI—No. 2, pp. 364, 384. Vol. VII—No. 4, p. 235.
Vol. VIII—No. 1, p. 311; No. 2, pp. 387, 439.

GENERAL SCIENCE IN OTHER SCHOOLS

Vol. I—No. 1, pp. 10, 46; No. 2, p. 126; No. 4, pp. 191, 223.
Vol. II—No. 1, pp. 255, 267; No. 2, p. 318; No. 4, p. 429.
Vol. III—No. 2, p. 82; No. 4, pp. 160, 226;
Vol. V—No. 4, p. 207. Vol. VI—No. 2, p. 373.

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Vol. I—No. 1, pp. 5, 52. Vol. V—No. 1, p. 1; Vol. VI—No. 4, p. 522.
Vol. VII—No. 2, p. 79. Vol. VIII—No. 3, p. 473. Vol. IX—No. 2, p. 96.

RELATION OF GENERAL SCIENCE TEACHING TO THE OTHER SCIENCES

Vol. I—No. 1, p. 17. Vol. II—No. 3, p. 381. Vol. IV—No. 1, p. 263; No. 3, p. 381. Vol. VI—No. 1, pp. 277, 284, 292; No. 2, p. 355.

HISTORICAL

Vol. I—No. 4, p. 200. Vol. VII—No. 3, p. 211. Vol VIII—No. 1, p. 349.
Vol. IX—No. 4, p. 249.

SCIENCE CLUBS

Vol. IV—No. 2, p. 310. Vol. VII—No. 1, pp. 1, 16.

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Volta's Discovery (1 reel), Atlas Educational Film Co., 111 South Blvd., Oak Park, Ill. The history of the science of battery making.

Civilization's Fabric (2 reels), Converse & Co., 88 Worth St., New York. The production and milling of cotton.

The Romance of Cloth (1 reel), National Motion Picture Bureau, Indianapolis, Ind. "From cotton to cloth" and "from wool to cloth," brief summaries of the processes of textile manufacturing.

Our Daily Bread (1 reel), General Electric Co., Schnectady, N. Y. The development of methods for harvesting, milling, and baking.

The Rubber of Yesterday (1 reel), Goodyear Rubber Co., Akron, Ohio. Rubber as produced in the jungle.

The Staff of Life (1 reel), National Motion Picture Bureau, Indianapolis, Ind. A history of bread making from colonial times to the present.

The Walworth Craftsman (1 reel), National Motion Picture Bureau. A novel presentation of the subject of fittings and tools for steam, water, air, gas, and oil control.

Manufacturing Atlas Portland Cement (1 reel), Alexander Leggett, New York. Emphasizes the function of science in the industry.

More Specific Teaching Aids Wanted

The editor has had several requests for more lesson plans and specific teaching aids. If you have worked out a project or a method of presentation of some particular topic, which is not given in the current texts, and which you have found helpful, send us an account of it, that we may pass it on to others through this magazine.

Would the readers of the General Science Quarterly care for a department where questions regarding science teaching problems would be answered?

Out of the Shadows

The motion picture as a messenger of good health and an agency for the prevention of the spread of disease has proved its value in the instance of "Out of the Shadows," a United States Department of Agriculture educational film.

This picture tells of the danger to human health from tuberculous dairy cattle and recommends methods of stamping out the disease. A human interest story running through the film brings home the moral of the story and helps to stir the audience into a definite plan of action.

"Out of the Shadows" has been exhibited in every agricultural county of the United States. Nearly one hundred copies of the film are kept in constant circulation, and in many instances the showing of this film has resulted in county or statewide campaigns to wipe out tuberculosis in dairy cattle.

Peanuts — $30,000,000 Worth

How the humble peanut is closely allied with American history is told in the United States Department of Agriculture educational firm, "Peanuts—$30,000,000 Worth."

This vegetable, which is not actually a nut but a ground pea, is a native South American plant and found its way to North America by way of Africa as food for prisoners on board slave ships in early Colonial days. Up to the time of the war between the States the plant was neglected by the southern planters and was grown mainly in small patches by the slaves. During the war Union soldiers foraging for food came upon the "goober pea" and found it palatable and nourishing. After Appomattox many of them carried the pods home with them, and the peanut won immediate favor in the North, and its culture has undergone great development in the South.

It Has Been a Warm Year

For the past eight months of the year, in most parts of the country, the temperature has tended to be above normal, and temperatures for September show the same general tendency so far, though records are not yet completed. During February, March and April it was warmer than usual over the entire country, from coast to coast and from Mexico to Canada. That is to say, in practically every section temperatures ranged several degrees higher than the average for that section during that month. One frequently finds that when it is cold in the states east of the Rockies, it is warm in the western group, and vice versa, but this year general, and in some regions, unusual warmth has been universal for long periods.

The Weather Bureau of the United States Department of Agriculture does not believe that the world is therefore getting warmer, nor does it offer any explanation for the warm conditions that have prevailed, but it gives interesting facts in connection with these above-normal temperatures.

In Georgia and other southeastern states there has been a general drought all summer, resulting in widespread crop loss. From 4 to 19 inches deficiency in rainfall is shown during the first eight months of the year over a large portion of the South and Southeast. In the vicinity of Washington, D. C., the deficiency in precipitation has been 11 inches. The very high temperatures which have prevailed throughout the Central and Southern states during several weeks have greatly augmented the ill effects of the rainfall shortage.

The effects of the drought in Nashville, Tenn., are unprecedented. This city had next to its lowest known precipitation in August. Use of water in the city has been restricted for several months. Wells have gone dry, some for the first time in their history, and the river has been the lowest on record. Montgomery, Ala., has just experienced the driest August in 53 years, with the river at its lowest point. Norfolk, Va., has also had the least rainfall for August in 53 years, and Elkins, W. Va., the least for 25 years. On August 14 the temperature at Charleston, S. C., reached 102 degrees F., the highest ever known in August in that city.

The New Books

Chemistry Experiment Sheets—Mendel and Brundage—59 experiments—Globe Book Co.

This is a manual of printed directions for chemistry laboratory experiments after the style of the loose-leaf manuals, but in this case, bound. A blank page is inserted after each experiment for the writing up of the experiment and for diagrams. Spaces are left on the page of printed directions for recording of data and the completion or writing of equations. In some cases competition questions are given. Each experiment consists of a list of apparatus and material, directions interspersed with questions on the work, directions for writing a conclusion, and a few general questions applying the principles studied in the experiment.

Elements of Electricity—Bliss—494 pages—numerous cuts—$1.96—Henry Holt and Co.

This text is arranged specifically for trade schools or electrical engineering work in junior colleges. The book is divided into two parts. The first part, consisting of fourteen chapters, aims to give a general survey of the field of electrical work. In order to gain a general comprehension of electrical principles it is sufficient to read merely the first section. This much of the text would make valuable reading for the general science teacher and might prove of interest to the brighter students in junior high schools who were interested in electrical engineering. The remaining thirty-one chapters are the application and extension of the fundamntals previously mentioned. This second section contains numerous problems.

Introduction to Earth History—Shimer—411 pages—141 cuts—Ginn and Co.—$3.00.

This text is planned to serve as a general survey to introduce the student to the more detailed knowledge of the earth that can be gained through chemistry, physics, astronomy, geology and biology. It is unique in accomplishing a remarkably unified conception of the history of the earth and its life, in presenting successfully a broad view briefly, and in an excellent arrangement of topics, with summary diagrams, topical reviews, and original illustrations. As the author points out, it is a "picture of the earth and its life as a consequence of processes which for unmeasured time have operated throughout the universe. It traces on the one hand the sequence of causes and effects which have produced the earth as we know it today, and on the other the succession of living forms which have made the earth their home."

The Branom Practice Tests in Geography—M. E. Branom—255 sheets—MacMillan.

These tests consist of one hundred and seven lessons, arranged in block form, so that the sheets may be torn off as needed. The tests are of various types of the newer kind, such as the one-word answer, the pairing of correct words in two groups, true and false, selection of correct answer, etc. Numerous maps are given with key numbers which serve as answers to some of the questions. Possible points for each exercise is given. The standard may be varied by the teacher to suit local needs. In the front cover is given a table for keeping the scores which when completed will give the pupil's score for the whole course at a glance.

The Continents and Their People—Africa—Chamberlain and Chamberlain—206 pages—79 cuts—MacMillan.

This is one of the series of supplementary geography readers covering, besides Africa, North and South America, Europe, Asia, and Oceania. The revision of this series has been made necessary by the changed conditions resulting from the World War. The new material is accurate and up to date, both as to text and maps. Though Africa was not directly interested in the issues that brought on the war, it was seriously involved. "Africa is now very much less the 'Dark Continent' of tradition. In the very near future the children who are in our schools today will be finding use for all of the sympathetic interest and intelligence with respect to Africa that teachers can give them. To this purpose the material in this volume has been revised, brought up to date, and enriched." A new feature are the thought problems to be found in the last chapter. Through this teaching aid, memory, imagination, and the thoughtful combination of facts may be brought into play here through the use of description, the story, the travelogue, or exposition.

A Student's Laboratory Manual and Note Book in General Science—Clement—Iroquois Publishing Co.

This is an exceptionally valuable notebook of this type. The material covers the work in seventh, eighth and ninth grades, but is so arranged that by following a key list it serves for a one-year course where General Science is given in High School in a city, or two where the Junior High School has not been organized. This arrangement of a three-year course should be very valuable, as in school systems where science is given in all three grades this avoids the overlapping which now so often takes place. The pupil may keep his one note book through the three years of science.

If space permitted, I would like to reprint the aims and organization given in this book. The seven aims and fifteen points in method of presentation are worthy of much consideration, and would serve as a brief treatise on how to use the laboratory and demonstration in general science teaching.

The complete course of study, as given, makes a good teaching outline. Special directions are given the pupil as to procedure in the investigations of an industry or a public utility. Each experiment is made up of "Object," "Materials," "Notes," "Method," "Observations," and "Conclusions." Under "Observations" questions are asked and hints given to direct the pupil's attention to points which might easily be overlooked, yet he is not told what to see. Under "Conclusions," leading questions are asked, the answers to which are found in the work of the experiment and which serve to state the attainment of the object. Space is left for the student's observations, conclusions and drawings. At the end of the book is a glossary of scientific terms used.

Health Through Prevention and Control of Diseases—Wood and Rowell—122 pages—$1.00—World Book Co.

This book presents a definite, systematic plan or program for the prevention and control of contagious diseases in schools. It is a handbook for teachers, for school physicians and nurses, for parents, for everyone concerned with health among school children. This book sums up the whole problem of prevention of contagious diseases, making available material nowhere else accessible under one cover. It is the purpose of the book "to give constructive help in the campaign to substitute health for disease in every school. The book is simple and non-technical enough for use by any teacher.

An Arithmetic for Teachers—Roantree and Taylor—621 pages—Macmillan.

"The writers feel that a teacher should have in his possession a book that contains the following information: 1. The explanation or definition of every term occurring in the subject of arithmetic that he might be called upon to explain. 2. A proof for every rule and principle occurring in the subject of arithmetic. 3. An explanation of the steps in the performance of any of the operations of arithmetic, a discussion of their logical sequence, and a good form for the written work of the operations. 4. A full explanation of how to solve problems arithmetically, a briefer explanation of various other methods of solution, and an analysis of what constitutes good problem material. 5. A few historical notes on various topics taught in arithmetic. 6. Approved methods for teaching the different topics in an elementary course in mathematics. 7. An analysis of the different types of lessons to be taught and of the method which is best adapted to each type. The authors in this volume have attempted to cover all the points mentioned above. In other words, they have been guided by the twofold purpose of providing in one volume (1) a book of information on various items to be taught in arithmetic, and (2) a discussion of presenting this knowledge to the child."

Each chapter is divided into two parts: "Teacher's Knowledge," and "Methods of Teaching." Certainly every teacher of arithmetic in the elementary grades should have this book.

High Lights of Geography—Europe and North America (two books)—Jordan and Cather—320 and 358 pages—numerous cuts—each book $1.44—World Book Co.

High Lights of Geography make evident to the child why the geography which he studies is what it is. They account for things as they are by natural law, dealing in narrative form with great fundamental principles. This is a feature that sets these books apart from the ordinary geographical reader. They do not give the usual cut-and-dried account of countries and products. Relation between the natural features and the life of today is purposely subordinated to supplying that descriptive setting which makes real the forces that have governed man's advance. To the authors of these books, the true high lights of geography are the interesting accounts which make clear the basic facts of geography, but which receive inadequate attention in the regular textbook. They give first attention to the geological origins of geography. High Lights of Geography treat expansively and graphically of mountains, rivers, lakes; of the treasures of coal, iron, oil and gold in the earth, and of life upon the earth. They make familiar and understandable such marvels of nature as the Rainbow Bridge, the Grand Canyon, volcanoes, caverns, America's big trees and oil fields, and Europe's storied heights and changing shore lines. Many airplane photographs provide unusual views and make it possible to study mountain tops and river beds in a new way.

A list of the chapter headings from the book on Europe will best illustrate the geological point of view: 1, Europe's Changing Shores; 2, The Work of Glaciers in Europe; 3, Volcanic Action in Europe; 4, Storied Heights; 5, The Uplands of Central and Southern Europe; 6, The Great Streams of Europe; 7, Waterways of South and North; 8, Erosion by Sea and River; 9, Woodlands of the Old World; 10, Creatures of the Wild; 11, From Savagery to Enlightenment, a Story of Early Man in Europe.

Handbook of Physics and Chemistry—Hodgman and Lange—903 pages—$5.00 (special discount to teachers and groups of students—Chemical Rubber Company.

The tenth edition of this handbook is now issued. This handbook is revised every year, and up-to-date and additional material is included. This handbook presents in a condensed form a very large amount of accurate and reliable information in the fields of chemistry and physics. In this edition data for about one thousand organic compounds has been added. New tables are given for the computation of inductance and capacity to meet the need in the field of radio. Other new tables added are: Trade Names of Dyestuff Intermediates, Standard Wave Lengths, Selective Absorption of Pigments and Dyes, and Isotopes. The section heads are as follows: Antidotes for Poisons, Burns and Scalds, Mathematics Tables, General Chemical Tables, Properties of Matter, Heat, Hygrometric and Barometric Tables. Sound, Electricity and Magnetism, Light, Definitions and Formulae, Laboratory Arts and Recipes, Photographic Formulae, Measures and Units, Wire Tables, Methods of Solving Problems in Chemistry and Elementary Physics.

Chalk Talks on Health and Safety—Dr. Walter F. Cobb—243 pages—many illustrations—MacMillan.

This is a group of very cleverly written stories on health and safety topics for young children. It is illustrated by the author with many clever and humorous blackboard drawings which may be used in the classroom to illustrate these stories as they are told to the children. The drawings are simple, of the line cartoon type, so that they may be reproduced easily on the blackboard by any teacher.

Bibliography of Science Teaching in Secondary Schools—U. S. Dept. of the Interior—Bureau of Education Bulletin No. 13 (1925)—20 cents.

This is a very extensive bibliography of articles pertaining to science teaching which have appeared in the leading educational journals.

Oceania—The Continents and Their People—Chamberlain and Chamberlain—169 pages—83 cuts—Macmillan.

This is a supplementary geographical reader. This text gives not only a knowledge of physical features, but also an interesting picture of the life, commerce, social and political institutions, and points of contact with this country. Some very good projects are given.

Quantitative Analysis—Prof. James M. Hendel—Ginn and Co.

This text presents in brief, concise and simple form, the fundamental principles of analytical chemistry; and illustrates them with the best typical methods, given in detail. Appended to each type method is a list of determinations involving the same theory. In this way the student becomes familiar with a large number of reactions, and gets a good general survey of the subject. Throughout the text the emphasis is laid on the theory involved. To this end the procedures are well annotated, so that the student cannot perform the experiments without realizing what he is doing. Experiments are arranged from the simpler to those requiring more technical skill, and as a further help to the student the subject of errors is discussed at length in a separate chapter. The subject is treated from the point of view of the modern ionic theory. A chapter on potentiometric methods as applied to acidimetry and to oxidation-reduction reactions is included.

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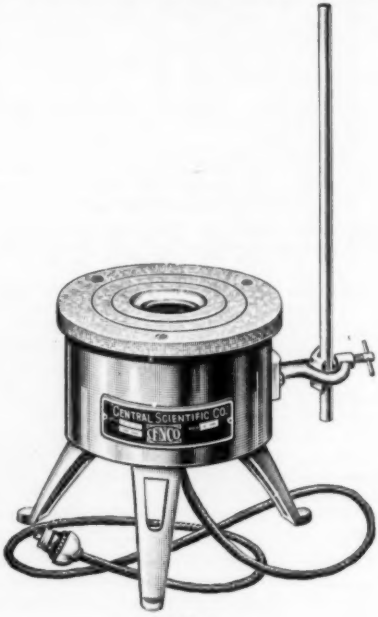

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460 E. Ohio St., Chicago, U.S.A.

An Elementary Manual of Physiology—Burton-Opitz—413 pages—147 cuts—$2.50—W. B. Sanders and Co.

Although this is a textbook "for colleges, schools of nursing, of physical education, and of the practical arts," it would be of great value to the biology or general science teacher. This book gives a complete but clear description and explanation of its subject matter. The sectional divisions are as follows: 1. Muscle and nerve; 2. Circulation of the blood and lymph; 3. Respiration; 4. Nutrition; 5. The nervous system; 6. The sense organs.

Everyday Science Projects—Smith—341 pages—156 cuts—96 cents—Houghton, Mifflin Company.

This text is for Grades 5, 6 and 7. It gives directions for over 300 projects. The material is very good and the directions for the projects are simple enough to be followed by the pupils, with very little attention from the teacher. They are so written as to stimulate the interest of the pupil, so that he will have a *desire* to carry out the work. The arrangement of the work follows the seasons. Therefore material is always available. During the winter time, when there is the least outdoor work, projects in light mechanics and electricity are introduced. The method of presentation is especially well adapted to the grades. An interesting feature is a method of self scoring that may be used to develop competition among the pupils. Good bibliographies are given.

Essentials of Design—Charles De Garmo and Leon L. Winslow—255 pages—Illustrated—The Macmillan Company.

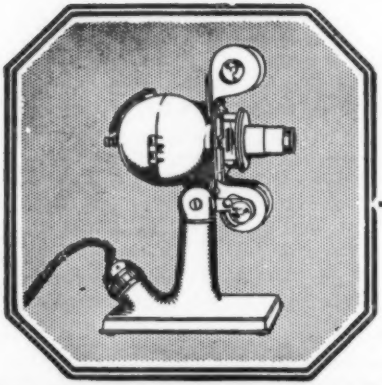
A book for all who are interested in design in industry and in the home. It treats: ancient and modern conception of industrial arts; abstract principles of design; conditions that control modern designs; the artistic significance of color; decorative designs; home decoration and furnishing; art in dress. The book is suitable for a text in schools.

A Text Book of General Botany—William H. Brown—484 pages—518 illustrations—$2.98—Ginn & Company.

This book gives the student a broad outlook of the whole field of botany, which is treated from the standpoint of general principles. "The greater part of the book is devoted to morphology, physiology, and reproduction of the seed plants." The drawings are excellent, and were made especially for this book. The chapters are: Introduction, Plant and its Environment, Heredity and Evolution, The Fruit and Seed, Division, *Thallophyta*, Division, *Bryophyta*, Division, *Pteridophyta*, Division, *Spermatophyta*, and Plant Geography.

AN UP-TO-DATE BIBLIOGRAPHY

There has been published a bibliography, "The High School Science Library," by Ranor A. Webb, George Peabody College for Teachers. The author has compiled this list with three points in mind. To obtain a place in this list the book must be up to date, accurate, and of style and vigor to fire the imagination of young people. It is an exceptionally valuable list. The full names and addresses of all of the publishers are given. To serve the library with a definite amount of money to spend, the list has been divided into seven sections, each group totaling a certain round sum of money in price. Twenty-five dollars buys the entire group of books recommended to the library with only twenty-five dollars to spend; twenty-five dollars additional completes the fifty-dollar list; fifty dollars additional completes the hundred-dollar list; one hundred and fifty dollars additional completes the two hundred and fifty-dollar list; and so on to one thousand dollars and over. These lists may be purchased from the author at cost.



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SEND FOR DESCRIPTIVE LITERATURE

Science Articles in Current Periodicals

[These classified articles should make supplementary reading for the pupils. In some cases the material is in a form which would be too difficult for the pupil to read the article himself. In such cases the article may be read by the teacher and the subject matter passed on to the pupil. Such articles are starred. Articles for professional reading are at the end of the classified list.]

ALCOHOL

The Motor Fuel of the Future. Lit. Dig., Nov. 14, 1925, p. 23.

ASTRONOMY

Stellar Speedsters. Lit. Dig., Dec. 12, 1925, p. 26.
A New Piece of Demonstration Apparatus to Show the Effect of the Ecliptic in causing Seasons, Variations in Length of Day and Climatic Zones of the Earth. Pop. Astron., Nov. 1925, p. 575.
The Moons of Mars.
Colligation of Martian Markings. Pop. Astron., Oct. 1925, p. 497.
Shadow Bands. Sci. Mo., Dec. 1925, p. 654.
Another Eclipse—What It May Tell Us. Pop. Sci. Mo., Jan. 1926, p. 25.

ATOMS

Can We See Atoms? Sci. and Inv., Jan. 1926, p. 811.
The Atom—Radio Talk. Sci. Mo., Nov. 1925, p. 449.

AUTOMOBILE

Driving a Car by Touch. Lit. Dig., Nov. 21, 1925, p. 23.
See also Alcohol and Fuel.

AVIATION

What Airways Promise Us. Pop. Mech., Nov. 1925, p. 32.
What Happened to the Shenandoah? Pop. Mech., Nov. 1925, p. 711.
The "Shenandoah" *versus* the Elements. Sci. and Inv., Nov. 1925, p. 605.
Meet the Autogiro. Lit. Dig., Nov. 21, 1925, p. 25.

BIBLIOGRAPHIES

A very good bibliography of supplementary reading is published in "The Science Classroom," Dec. 1925, published by the Pop. Sci. Pub. Co.

BIOGRAPHY

Youthful Achievements of Great Scientists. Sci. Mo., Nov. 1925, p. 522.
Inventions that Edison Still Hopes to Make. Pop. Sci. Mo., Jan. 1926, p. 14.

BRIDGES

*Research and Experimental Tests in Connection with the Design of the Bridge over the Delaware between Philadelphia and Camden.
*The Towers, Cables and Stiffening Trusses of the Bridge, etc. Jour. Frank. Inst., Oct. 1925, p. 417.

Rust Stains in Cotton

From *Fibre and Fabric.*

The British Cotton Industry Research Association says that the most efficient means found up to the present for removing rust stains from gray cloth consists in the use of a solution of one ounce of oxalic acid and one ounce of potassium hydrogen fluoride (acid potassium fluoride) in one quart of water. The stained cloth is placed on a pad of absorbent material and the stain dabbed with a small pad of cloth soaked in the cold solution until the stain disappears, the excess of the reagent being then removed by washing first with water and then with a little diluted ammonia to avoid leaving acidic substances on the cloth, which might cause tendering. The solution has been shown not to cause any appreciable tendering when left in contact with cloth for a period of 24 hours.

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BUILDING MATERIALS

The Use of Brick for Building.
Why Stucco for the Country Home. Garden and Home Build., Oct. 1925, p. 104.
Twenty-eight Day Concrete in Twenty-Four Hours. Lit. Dig., Dec. 12, 1925, p. 25.

COAL

What We Get from a Ton of Coal. Pop. Sci. Mo., Dec. 1925, p. 31.

COMMUNICATION

"Four Millions on 'Permalloy' to Win." Pop. Mech., Dec. 1925, p. 947.
*Telephone Picture Transmission. Sci. Mo., Dec. 1925, p. 562.
The Story of the Bell Telephone. The Experimenter, Jan. 1926, p. 138.

CONCRETE

See Building Materials.

DYEING

Further Notes on the Science of Dyeing. Dye Stuffs, Oct. 1925, p. 145.

EARTH

See Geology.

ECLIPSE

See Astronomy.

EDISON, THOMAS A.

See Biography.

ELECTRICITY

The Electricity of the Air. Sci. Mo., Dec. 1925, p. 641.

ELECTROPLATING

Electroplating. The Travelers' Standard, Oct. 1925, p. 212.
See Rubber.

ELEMENTS

Two New Elements Discovered. Sci. and Inv., Nov. 1925, p. 615.

FERTILIZERS

Muscle Shoals Complications. Ind. and Eng. Chem. News Edition, Oct. 10, 1925, p. 4.

FOOD

Learning to Feed the Army and Navy. Pop. Mech., Dec. 1925, p. 971.
The Story of Evaporated Milk. Am. Food Jour., Oct. 1925, p. 488.
Are Dried or Canned Fish Safe Foods? Hygeia, Nov. 1925, p. 649.
*Protecting the Consumer from Food and Drug Frauds. The Nation's Health, Oct. 1925, p. 667.

FOSSILS

See Geology.

FUEL

Petroleum Motor Fuel. Ind. and Chem. Eng., Nov. 1925. p. 1105.
See Alcohol and Coal.

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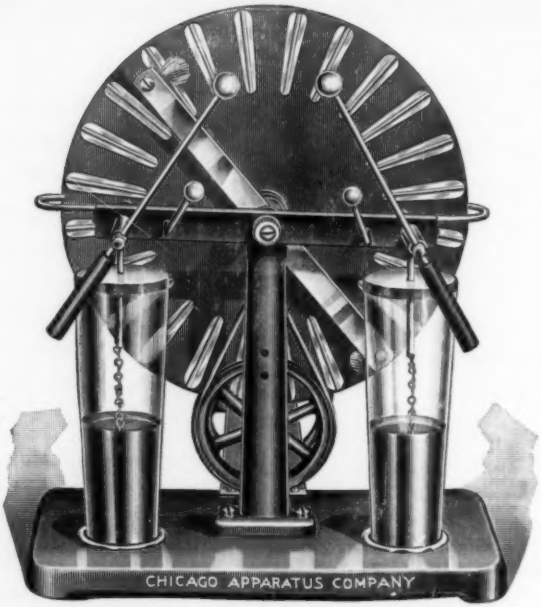

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GAS

The Life and Chemical Service of Frederick Accum. Chap. III. Jour. Chem. Educ., Nov. 1925, p. 1008.

GEOLOGY

Is the Earth Solid? Sci. Inv., Nov. 1925, p. 622.

A New Ice Age is Approaching. Pop. Sci. Mo., Nov. 1925, p. 42.

The Romance of Science in Polynesia. Nat. Geog., Oct. 1925.

*Fossil Logs and Nuts of Hickory. Sci. Mo., Dec. 1925, p. 570.

"World Apart" Yields Giant Bones. Pop. Mech., Dec. 1925, p. 941.

Turning Fossil Graveyard into Wealth. Pop. Mech., Dec. 1925, p. 991.

Moving Model of a Brontosaur. Lit. Dig., Nov. 21, p. 22.

Meteors—Radio Talk. Sci. Mo., Nov. 1925, p. 456.

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Quacks and Quackeries. Sci. Mo., Nov. 1925, p. 533.

*Astigmatism. Hygeia, Nov. 1925, p. 613.

See Foods.

HEATING

Heating the House Efficiently. Hygeia, Nov. 1925, p. 629.

Tricks in Burning Soft Coal. Pop. Sci. Mo., Jan. 1926, p. 34.

HEREDITY

What Kind of Children Will you Have? Pop. Sci. Mo., Nov. 1925, p. 25.

HOME ECONOMICS

The Sky as a Home Economics School Room. Am. Food Jour., Oct. 1925, p. 486.

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